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ADVANCED CONCEPTS FOR COMPOSITE STRUCTURE JOINTS AND ATTACHMENT FITTINGS

Volume II - Design Guide

J. V. Alexander and R. H. Messinger
Hughes Helicopters
Division of Summa Corporation
Culver City, CA 90230

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APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report consists of two volumes and identifies all design considerations, testing, and cost analysis pertinent to composite joints and fittings attachments. The approach used in this program was to identify generic types of joints and fittings applicable to helicopter composite primary structures; the design emphasized reliability and cost effectiveness. The technology developed in this program has been incorporated in the design of new major composite components such as tail sections, and the foundation for future R&D work has been laid.

Mr. Nick Calapodas of the Aeronautical Technology Division served as project engineer for this effort.

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The purpose of this program was to develop the technology of applying fiber-reinforced composite materials to helicopter joints and attachment fittings that permit disassembly of major components. A generic design methodology approach was used to make the data developed applicable to ongoing and future helicopter programs.

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A detail design, analysis, and testing program was carried out on the three joint and fitting concepts selected: wrapped tension fittings, gear box attachment fittings, and seat attachment fittings.

The scope of the study included analytical design tools, including finite element computer analysis; fabrication techniques, with special emphasis on weight and cost effectiveness considerations; structural integrity testing, including static, dynamic, failsafe/safe-life, and ballistic tolerance considerations; and nondestructive inspection (NDI) techniques.

This volume contains the analytical and experimental results of the laminated angle bracket study and the Design Guide, which covers each type of joint or fitting tested.

SUMMARY

This report was prepared by Hughes Helicopters, Inc. (HHI), Culver City, California 90230, for the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia 23604, under Contract DAAJ02-77-C-0076.

The purpose of this program was to develop the necessary methodology for applying fiber-reinforced composite materials to helicopter joint and attachment fitting designs that permit disassembly of major components.

For this program, primary joints and fittings representative of high-performance helicopters (the YAH-64 in particular) were selected for evaluation. A generic design methodology approach was used to make the data that was developed applicable to ongoing and future helicopter programs.

The objective of this program was to develop basic concepts for competitive helicopter joints and fittings using composite materials. These materials must be capable of being readily integrated into composite components and attached to other components, both composite and metal, such that the weight and cost effectiveness of the advanced composite component is an improvement over the baseline metallic component alternatives.

All detail design and fabrication aspects of the three advanced composite joint and fitting types that were fabricated and tested during this contracted effort are documented in this report, along with the analytical and experimental results of the laminated angle bracket study.

TABLE OF CONTENTS

	Page
SUMMARY	3
LIST OF ILLUSTRATIONS	8
LIST OF TABLES	12
INTRODUCTION.	14
DESIGN PROPERTIES	19
Composite Allowables	19
Angle Allowables	21
DRAWING PREPARATION	24
Ply Orientation	24
Stacking Sequence	24
FUSELAGE-TAILBOOM JOINT (TYPE A)	27
Design Criteria	27
Stress Analysis	29
Fabrication Methods	29
SPAR BOX-RIB JOINT (TYPE D)	31
Design Criteria	31
Stress Analysis	31
Fabrication Methods	33

TABLE OF CONTENTS (CONT)

	Page
COPILOT SEAT FITTING (TYPE K)	35
Design Criteria	35
Stress Analysis	35
Fabrication Methods	37
INSPECTION METHODS	38
COST/WEIGHT TRADE STUDY	39
FINITE ELEMENT ANALYSIS	41
Angle Bracket Model	41
Individual Joint Models	41
BIBLIOGRAPHY	52
APPENDIXES	
A COMPOSITE MATERIAL ALLOWABLES	53
B ANGLE BRACKET STUDY	69
C C-1 MODEL PREPROCESSOR PROGRAM LISTING	123
D C-1 PREPROCESSOR FLOWCHART	138
E C-1 MODEL PREPROCESSOR PROGRAM OUTPUT	144
F C-1 MODEL PREPROCESSOR PROGRAM BULK DATA LISTING	162
G C-1 PLOT RUN DATA DECK SETUP AND UNDEFORMED PLOTS	168
H C-1 SOLUTION RUN OUTPUT	173
I C-2 MODEL PREPROCESSOR PROGRAM LISTING	190

TABLE OF CONTENTS (CONT)

		Page
J	C-2 PREPROCESSOR FLOWCHART	192
K	C-2 MODEL PREPROCESSOR PROGRAM OUTPUT	195
L	C-2 PLOT RUN OUTPUT AND UNDEFORMED PLOTS	198
M	SINGLE STRIP NASTRAN OUTPUT	216
N	ACRONYM DEFINITIONS	241
O	STRESS ANALYSIS	242

LIST OF ILLUSTRATIONS

Figure		Page
1	Fuselage-Tailboom Joint	15
2	Spar Box-Rib Joint	16
3	Copilot Seat Fitting	17
4	Joint and Fitting Design Flowchart	18
5	Fiber Orientation	21
6	Angle Joint Allowable Loads	22
7	Fiber Orientation Reference Axis	24
8	Stacking Sequence	25
9	Ply Sequence Schematic	26
10	Final Detail Design: Type A	28
11	Manufacturing Steps: Type A	30
12	Final Detail Design: Type D	32
13	Manufacturing Steps: Type D	34
14	Final Detail Design: Type K	36
15	Manufacturing Steps: Type K	37
16	Break-Even Partitioning of Composite Fittings	39
17	Cost vs Weight Relationship of Composite Fittings	40

LIST OF ILLUSTRATIONS (CONT)

Figure		Page
18	Typical Laminated Angle Bracket	42
19	NASTRAN Model C-1	43
20	NASTRAN Model C-2	44
21	Normalized Shear Stress vs Bracket Angle and Width	45
22	NASTRAN Model of Joint Type A (Top View)	46
23	NASTRAN Model of Joint Type A (Side View)	47
24	NASTRAN Model of Joint Type D (Top View)	48
25	NASTRAN Model of Joint Type D (Side View)	49
26	NASTRAN Model of Joint Type K (Front and Side Views)	50
27	NASTRAN Model of Joint K (Internal Loads)	51
B-1	"Bathtub" Tension Fitting	69
B-2	Turning the Corner	71
B-3	Internal Loads in the Corner Region	73
B-4	Laminate Geometry	74
B-5	Angle Bracket Subdivision	76
B-6	Single-Layer Model	77
B-7	Two-Stage Computer Analysis Flowchart	79
B-8	C-1 Coordinate Systems	81
B-9	Grid Point and Element ID Numbers	83

LIST OF ILLUSTRATIONS (CONT)

Figure		Page
B-10	C-1 Boundary Conditions	88
B-11	Rotation of Axis	90
B-12	Load Conditions	91
B-13	Sample Input Data for Multilayer C-1 Model Preprocessor Run	94
B-14	Critical Strip Model	96
B-15	Sample Ten-Strip Model	98
B-16	Tangential Stress Versus Bend Angle Along the Centerline Strip: Uniform Tension Load Case	99
B-17	Tangential Stress Versus Angle Width: Uniform Tension Load Case	100
B-18	Interlaminar Shear Stress Versus Bend Angle: Uniform Tension Load Case	101
B-19	Interlaminar Shear Stress Versus Angle Width: Uniform Tension Load Case	102
B-20	Normal Stress Versus Bend Angle: Uniform Tension Load Case	103
B-21	Normal Stress Versus Angle Width: Uniform Tension Load Case	104
B-22	Laminated Centerline Strip of the Ten-Strip Test Model	105
B-23	Interlaminar Shear Stress Versus Bend Angle: Uniform Tension Load Case	106
B-24	Interlaminar Shear Stress Through the Laminate Thickness at θ = 5 and 75 degrees: Uniform Tension Load Case	107

LIST OF ILLUSTRATIONS (CONT)

Figure		Page
B-25	Normal Stress Along the Bend Angle: Uniform Tension Load Case	108
B-26	Normal Stress Through the Laminate Thickness at θ = 5 and 75 degrees: Uniform Tension Load Case	109
B-27	Interlaminar Shear Stress Versus Bend Angle: Uniform Clockwise Couple Load Case	110
B-28	Normal Stress Versus Bend Angle: Uniform Clockwise Couple Load Case	111
B-29	Tangential Stress Versus Bend Angle for Varying Thickness-to-Bend Radius Ratios: Uniform Tension Load Case	113
B-30	Tangential Stress Versus Bend Angle for Varying Stacking Sequences: Uniform Tension Load Case	114
B-31	Interlaminar Shear Stress Versus Bend Angle for Varying Thickness-to-Bend Radius Ratios: Uniform Tension Load Case	115
B-32	Interlaminar Shear Stress Versus Bend Angle for Varying Stacking Sequences: Uniform Tension Load Case	116
B-33	Four Stacking Sequences	117
B-34	Interlaminar Shear Stress for Varying Stacking Sequences Through the Laminate Thickness	117
B-35	Test Setup	120
B-36	Fracture Progression in Typical Composite Angle	121
B-37	Ultimate Allowable Loads Versus Thickness	122

LIST OF TABLES

Table		Page
1	Sample Stacking Sequence	25
A-1	Graphite Composite Properties	55
A-2	Graphite Moduli (VF = 0.55)	56
A-3	Graphite Moduli (VF = 0.60)	57
A-4	Graphite Strength Allowables (VF = 0.55)	58
A-5	Graphite Strength Allowables (VF = 0.60)	59
A-6	Graphite Poisson's Ratio and Thermal Expansion (VF = 0.55)	60
A-7	Graphite Poisson's Ratio and Thermal Expansion (VF = 0.60)	61
A-8	Kevlar 49 Composite Properties	62
A-9	Kevlar 49 Moduli (VF = 0.55)	63
A-10	Kevlar 49 Moduli (VF = 0.60)	64
A-11	Kevlar 49 Strength Allowables (VF = 0.55)	65
A-12	Kevlar 49 Strength Allowables (VF = 0.60)	66
A-13	Kevlar 49 Poisson's Ratio and Thermal Expansion (VF = 0.55)	67
A-14	Kevlar 49 Poisson's Ratio and Thermal Expansion (VF = 0.60)	68

LIST OF TABLES (CONT)

Table		Page
B-1	Input Parameter Names	86
B-2	Parametric Analysis	112
B-3	Angle Tension Test Specimens	119

INTRODUCTION

The purpose of this design guide is to document all detail design and fabrication aspects of three advanced composite joint and fitting types that were investigated under the Advanced Concepts for Composite Structure Joints and Attachment Fittings Program (Contract DAAJ02-77-C-0076). The three joint and fitting types analyzed are:

a. Type A — Fuselage-Tailboom Joint (Figure 1)

b. Type D — Spar Box-Rib Joint (Figure 2)

c. Type K — Copilot Seat Fitting (Figure 3)

The steps involved in the design, fabrication, and testing of the three joint and fitting types are illustrated in flowchart form in Figure 4. During the initial screening and evaluation phase of the program, the configurations and critical applied loads of the metal baseline joints were identified. Design concepts, composite materials, and fabrication methods selected according to structural efficiency, cost, and weight considerations were incorporated into the preliminary design drawings. Preliminary hand analyses of the joints were then carried out using conservative design allowables obtained from the existing data base.

A small number of each joint and fitting type were fabricated for tool proofing and subsequent testing by nondestructive methods (hammer tapping and harmonic analysis). Each joint and fitting was then tested statically, and Types A and D were also fatigue tested. The results of these experiments were compared with the analytical predictions discussed in Volume I of this report.

A cost effectiveness study was carried out to relate cost and weight differences between the composite joints and their baseline metal counterparts.

Finite element modeling consisted of a NASTRAN analysis to determine critical interlaminar shear properties in the radius of a general angle bracket, and NASTRAN models were prepared for each individual joint.

The experience and data gained from fabrication, testing, and modeling of these joints were used to finalize the detail design drawings. Accessibility, simplicity, environmental protection, weight, cost, and interchangeability were the factors weighed most heavily.

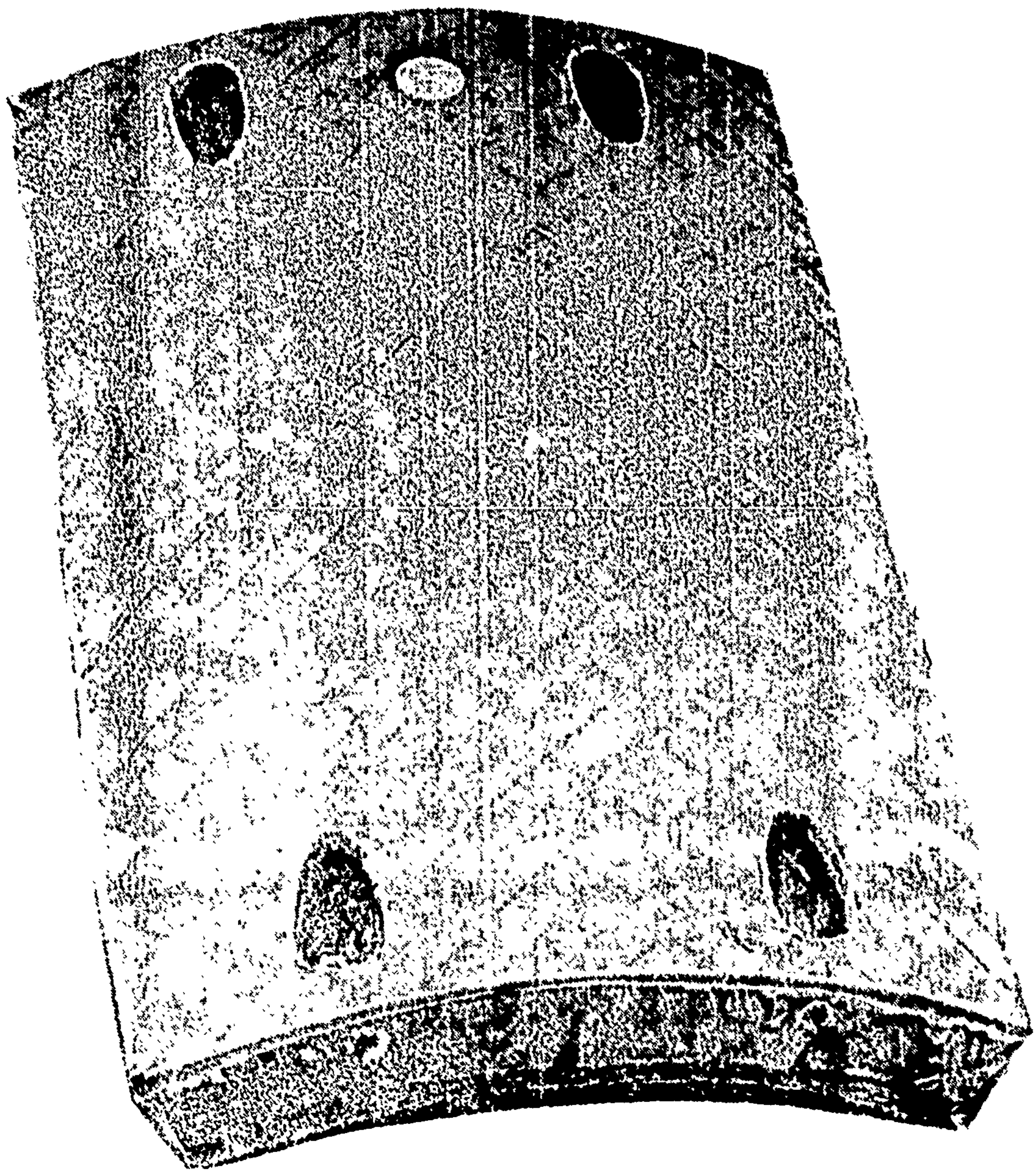


Figure 1. Fuselage-Tailboom Joint

Figure 2. Spar Box-Rib Joint

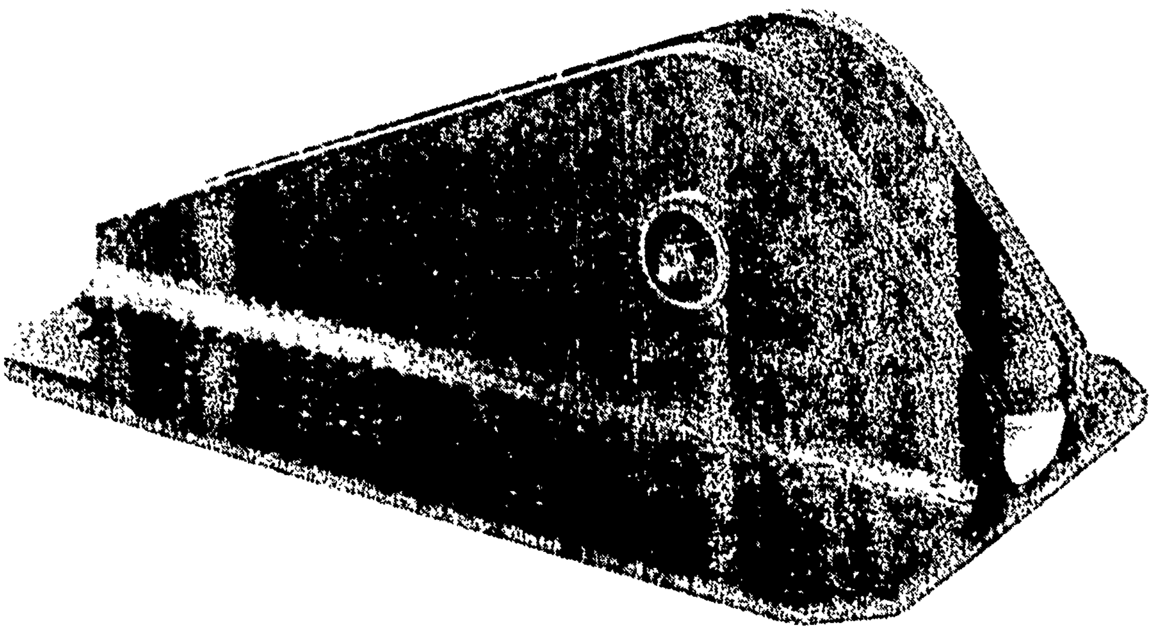


Figure 3. Copilot Seat Fitting

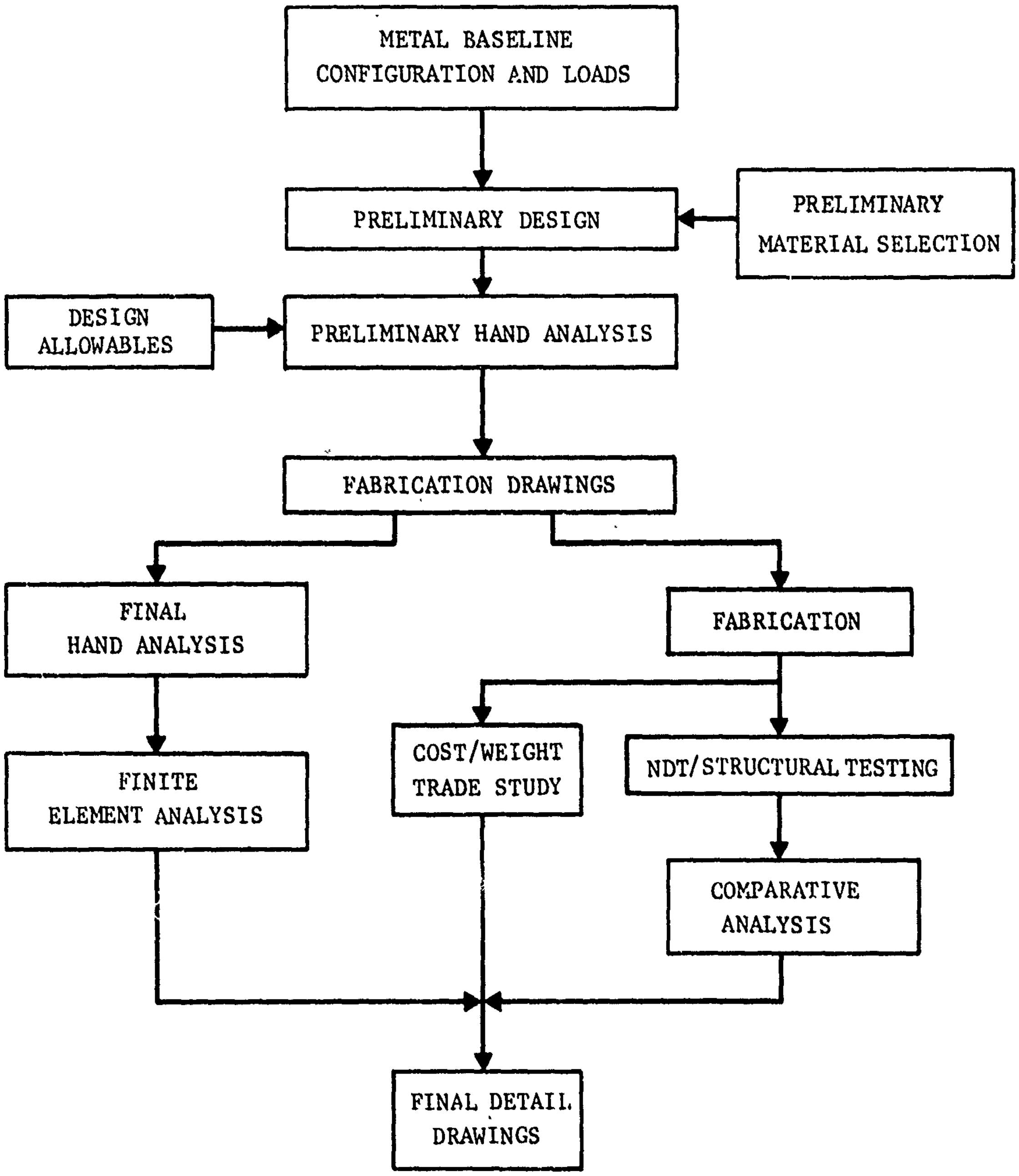


Figure 4. Joint and Fitting Design Flowchart

DESIGN PROPERTIES

The composite material allowables and angle properties in this report are given for Kevlar 49 aramid fiber and Thornel T300 graphite fiber impregnated with an epoxy resin system obtained from Applied Plastics Co., Inc. (2434 resin/2347 hardener). These materials have been qualified to HHI material specifications.

Either the wet filament winding or hand layup technique can be used according to HHI process specifications. The cure cycle for this resin system is:

a. 4 hr at 140°F ±10°F

b. 2 hr at 170°F ±10°F

c. 2 hr at 250°F ±10°F

COMPOSITE ALLOWABLES

The graphite and Kevlar composite allowables used in the design analyses of the joints were developed during previous work using advanced composite materials[1] and are reproduced in Appendix A. Laminate moduli, strength, and other physical property values are given as a function of fiber angle for fiber volume ratios of 0.55 and 0.60. The laminates are constructed of symmetric angle plied layers of $\pm\alpha$ (alpha) orientation. Fiber, resin, and composite input data terms are defined as:

AF (AR) = Fiber (resin) coefficient of thermal expansion, in./in./°F

AFT = Fiber transverse coefficient of thermal expansion, in./in./°F

EF (ER) = Fiber (resin) elastic modulus, psi

EFT = Fiber transverse elastic modulus, psi

[1] Goodall, R.E., ADVANCED TECHNOLOGY HELICOPTER LANDING GEAR, Hughes Helicopters, Division of Summa Corporation; USAAMRDL Technical Report 77-27, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, April 1977.

FCU = Fiber or composite ultimate compressive strength, psi

FSU = Resin ultimate shear strength, psi

FTU = Fiber or composite ultimate tensile strength, psi

GF = Fiber shear modulus, psi

RHO = Composite density, lb/ft^3

RHOF (RHOR) = Fiber (resin) density, lb/ft^3

UF (UR) = Fiber (resin) Poisson's ratio (dimensionless)

VF (VR) = Fiber (resin) volume, percent

WF (WR) = Fiber (resin) weight, percent

Composite properties are abbreviated as follows:

ALPHA = Fiber angle, deg

AX = Coefficient of thermal expansion, X direction, in./in./°F

AY = Coefficient of thermal expansion, Y direction, in./in./°F

EX = Elastic modulus, X direction, psi

EY = Elastic modulus, Y direction, psi

FXCU = Ultimate compressive strength, X direction, psi

FXTU = Ultimate tensile strength, X direction, psi

FXY = Ultimate shear strength, psi

FYCU = Ultimate compressive strength, Y direction, psi

FYTU = Ultimate tensile strength, Y direction, psi

GXY = Shear modulus, psi

UXY = Poisson's ratio, perpendicular to X direction (dimensionless)

UYX = Poisson's ratio, perpendicular to Y direction (dimensionless)

Fiber orientation with respect to the longitudinal (X) and transverse(Y) directions of the composite component is defined in Figure 5. The longitudinal direction is usually aligned with the primary load path of the component.

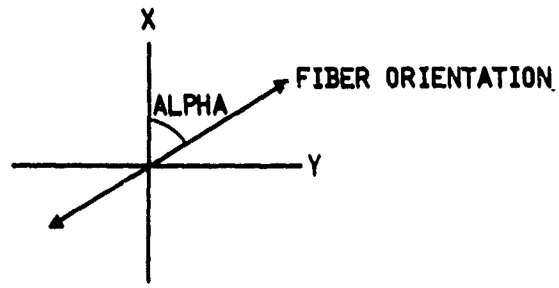


Figure 5. Fiber Orientation

The rule of mixtures method can be used with the property tables given in Appendix A to determine the laminate properties of any one type of fiber. For example, in a $(0/\pm45/90)_s$ graphite laminate with VF = 0.55, the longitudinal (X direction) elastic modulus is

$$\text{EX (laminate)} = \frac{2(18.91 \times 10^6) + 4(2.039 \times 10^6) + 2(9.106 \times 10^5)}{8}$$

$$= 5.975 \times 10^6 \text{ psi}$$

ANGLE ALLOWABLES

The simple turn-the-corner angle design shown at the bottom of Figure 6 can be used in many cases in which composite components must be capable of disassembly. One-inch-wide T300 graphite, Kevlar 49, E-glass, and

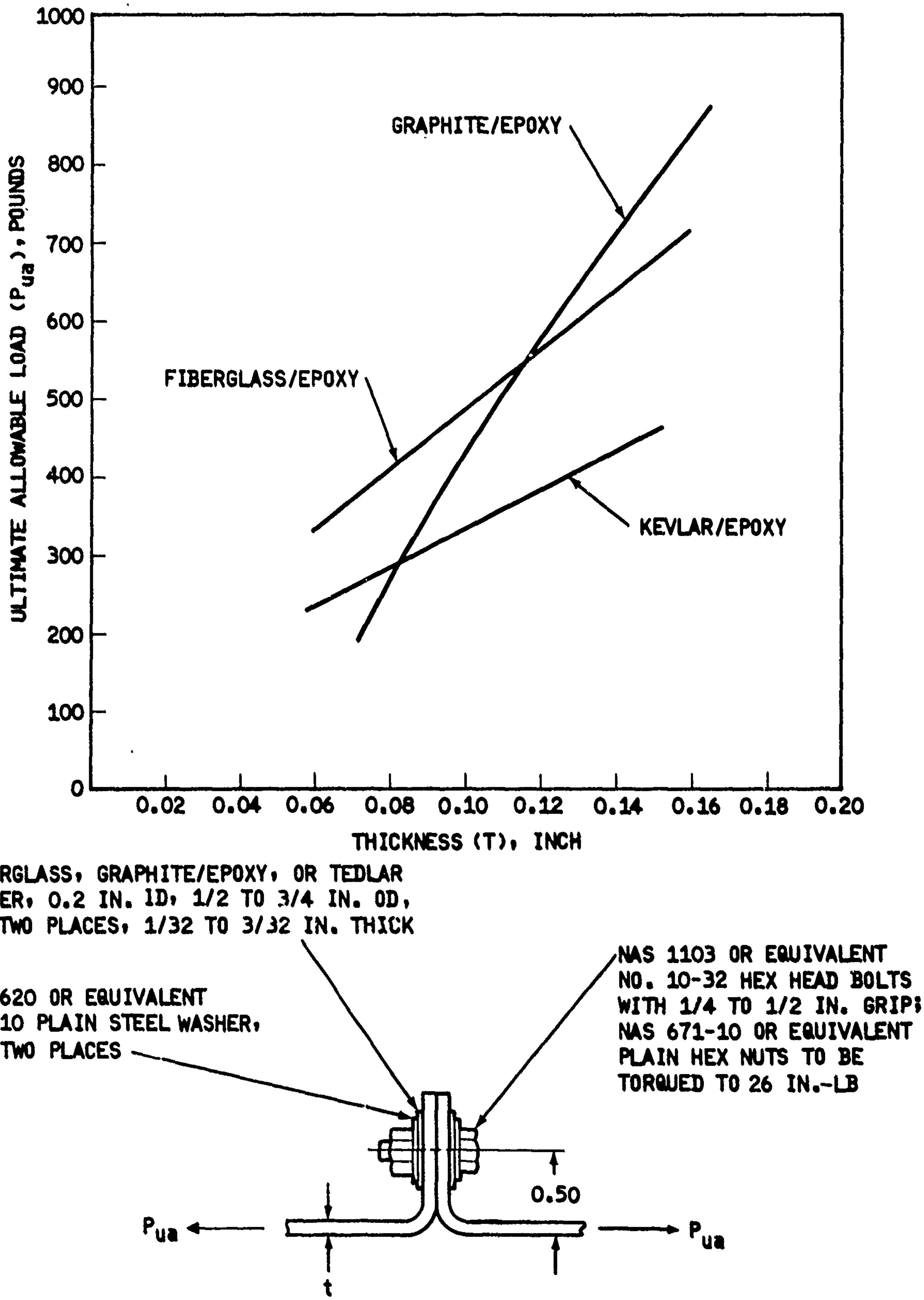


Figure 6. Angle Joint Allowable Loads

S-glass angle joints with repetitions of the (0/±45/90) layup sequence were fabricated and tested to determine their allowable ultimate strengths. Preliminary results of these tests are given below:

a. The corners of thinner angles straighten out elastically for a distance of up to two or three times their initial radii. Next the matrix fails in delamination, and finally the fibers fracture at ultimate load.

b. The concept of yield strength being two-thirds of ultimate strength is not transferable from metals to composites. Permanent set may occur anywhere from 75 percent (thin angles) to 90 percent of ultimate strength (thicker angles).

c. Thick sections are more ductile than thin ones.

d. Allowable load versus thickness in composite angles is shown in Figure 6 for an eccentricity of 0.5 inch. Composite angles of varying eccentricity and thickness must be tested before nomographs similar to those already well-established for aluminum can be developed.

DRAWING PREPARATION

A number of common industry practices are used in the detail design drawings to describe the composite components of the three joint and fitting types.

PLY ORIENTATION

The reference fiber orientation of a composite component is shown in Figure 7. The 0-degree direction is defined as the longitudinal, lengthwise, or major load direction of the component.

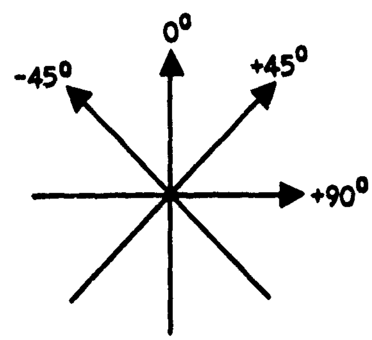


Figure 7. Fiber Orientation Reference Axis

STACKING SEQUENCE

The stacking sequence of any number of plies can be represented by giving the orientation of each ply or group of plies, separated by slashes, braces, and brackets according to a conventional system of notation. The stacking sequence of Detail 5 of Joint Type K is shown in Figure 8 as an example.

A stacking sequence table such as the one shown in Table 1 can be placed on the engineering drawing to help organize the stacking sequence and orientation of any relatively complex composite component.

A large-scale schematic detail of the component should be provided along with the stacking sequence table. In the cross section shown in Figure 9, each ply is drawn and appropriately identified so that ply dropoffs can be clearly defined. The minimum distance between ply dropoffs is 0.2 inch. The maximum thickness of each dropoff is 0.030 inch, which is approximately equivalent to two plies of fabric.

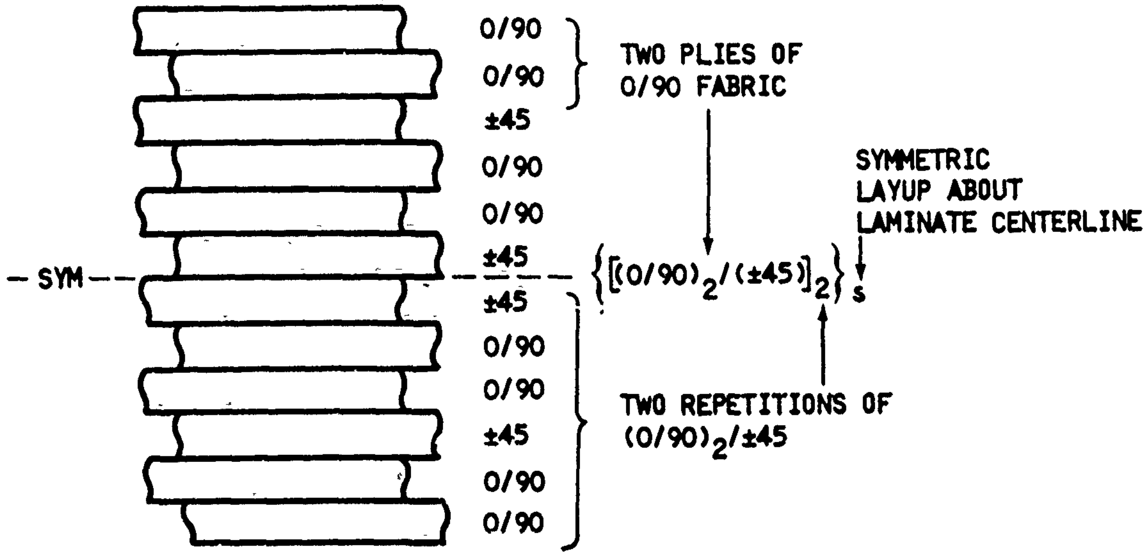


Figure 8. Stacking Sequence

TABLE 1. SAMPLE STACKING SEQUENCE

PLY NO.	PLY ORIENTATION	MATERIAL	PLY THICKNESS
P1	±45	7 8	0.0135
P2	±45		0.0135
P3	0		0.007
P4	0		
P5	0		
P6	0		
P7	0		
P8	0		0.007
P9	±45		0.0135
P10	0		0.007
P11	0		
P12	0		
P13	0		
P14	0		
P15	0		0.007
P16	±45		0.0135
P17	±45	7 8	C.0135

NOTE: 7 AND 8 REFER TO THE GENERAL NOTES ON THE ENGINEERING DRAWING IN QUESTION

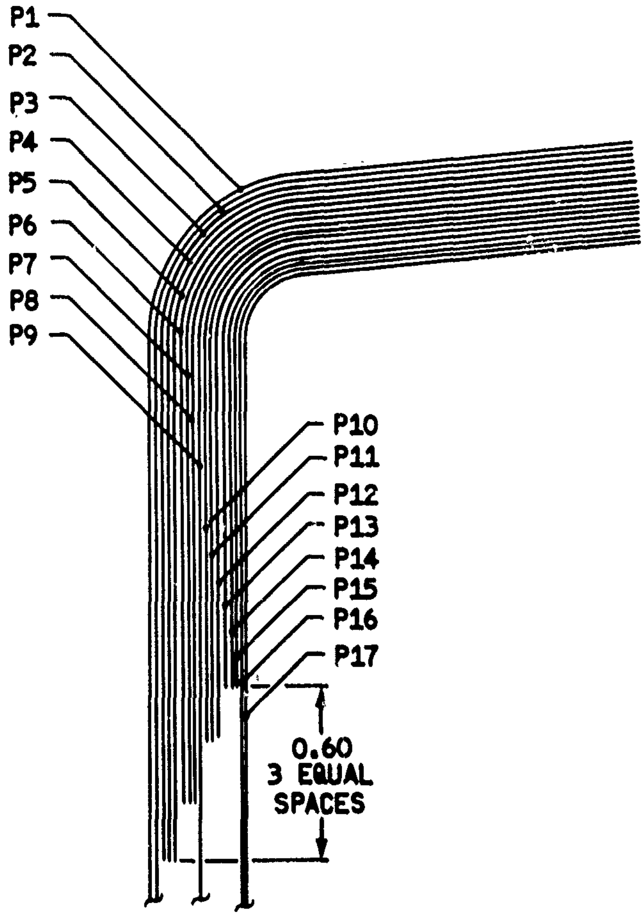


Figure 9. Ply Sequence Schematic

FUSELAGE-TAILBOOM JOINT (TYPE A)

Joint Type A represents the attachment of a composite helicopter tailboom to a forward fuselage. This tension bolt design includes steel fittings within a graphite/Kevlar hybrid channel, which is joined to the graphite/Kevlar hybrid skins of the sandwich structure.

The composite fuselage-tailboom joint incorporates design concepts and manufacturing techniques to minimize weight and cost while efficiently carrying ultimate loads. The final detail design of the test panel that incorporates this joint is shown in Figure 10.

DESIGN CRITERIA

The process of evaluating and comparing numerous design concepts and carrying out the final detail design was controlled by the following criteria:

a. Loads - Flight condition loads transferred across the fuselage-tailboom joint must be efficiently carried by either a tension bolt fitting or shear splice. The tension bolt concept was chosen to permit direct interchangeability with an existing metal tailboom.

b. Accessibility - Given the tension bolt concept, the composite tailboom should be attached from the outside. Access holes must therefore be provided in the skin or other integral fitting.

c. Simplicity - The wet-filament-winding/cocuring fabrication process eliminates much time and effort normally spent in secondary bonding or mechanical fastening of precured parts. Wet filament winding is especially applicable to fabrication of cylindrical structures such as tailbooms.

d. Environmental protection - Exterior helicopter components such as fuselage-tailboom joints are designed for improved environmental resistance in accordance with established HHI process specifications. External steel parts such as the -3 fitting are plated by various methods approved for aircraft structures. Nonmetallic external parts such as the -9 inner or -11 outer skins are primed before they are painted according to specification.

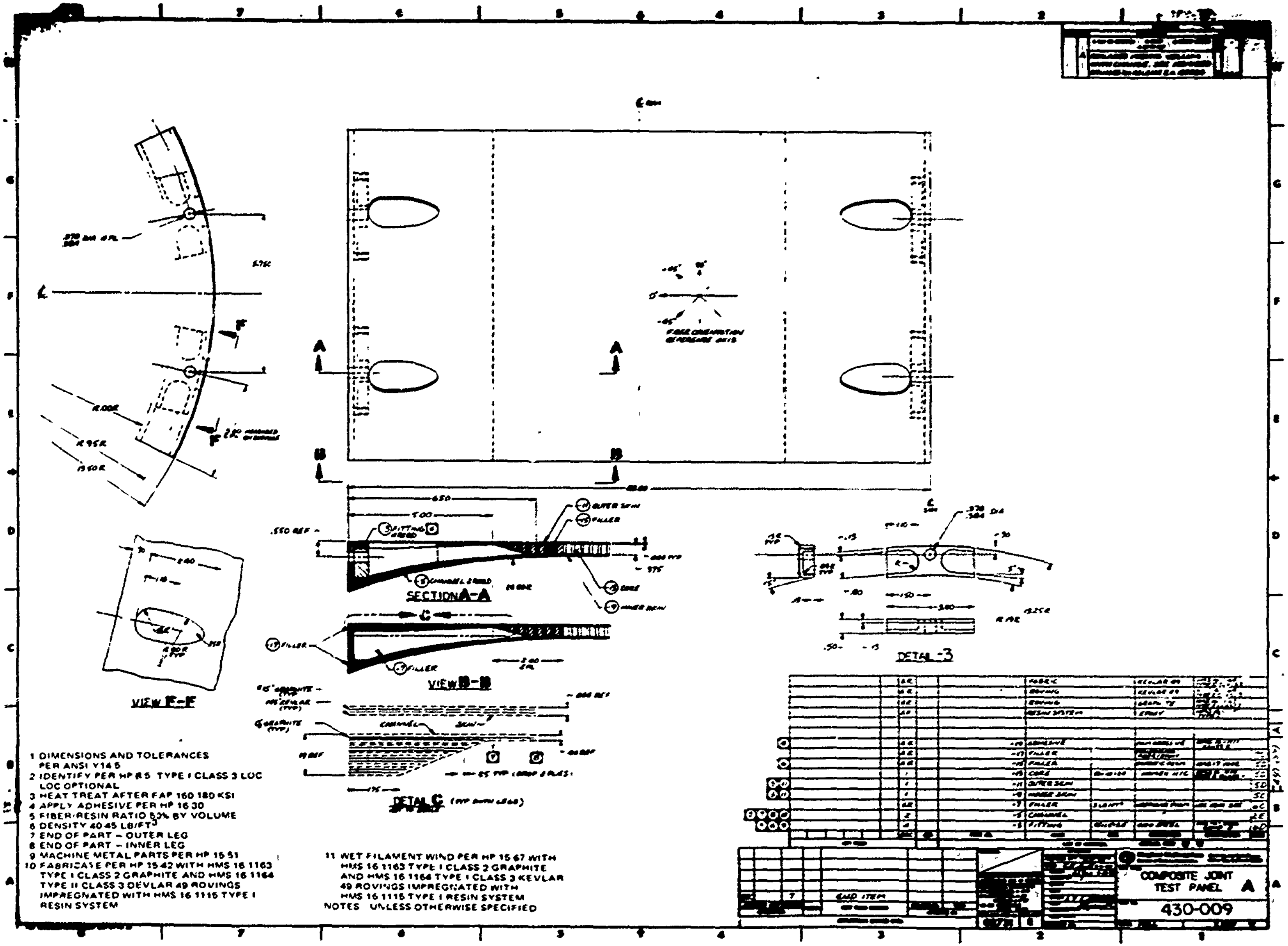


Figure 10. Final Detail Design: Type A

STRESS ANALYSIS

In the hand stress analysis of Joint Type A, the following loads and stresses were determined:

a. Critical ultimate loads due to crashworthiness conditions

b. Local -5 channel reaction load intensities in tension and compression

c. Fiber stresses in ±15° graphite and ±45° Kevlar

d. Shear stresses between the -5 channel and the outer facesheet

e. Lamina strains

f. Honeycomb sandwich buckling and wrinkling

g. Bending of the -3 fitting

FABRICATION METHODS

Joint Type A was fabricated to simulate the methods used to fabricate a composite tailboom, and so the inner and outer skins and the 0° plies of the -5 channel were fabricated using the wet filament winding method. The -5 channel was laid up manually on a male tool, using the 0° plies mentioned above and the ±45° Kevlar fabric, and then staged in a vacuum bag. The channel was trimmed, assembled with honeycomb core, and cocured with the skins. Pressure during cure was provided by hoop-wound filaments (90°) rather than by vacuum bag or autoclave to avoid collapsing the mandrel. No film adhesive was used because the skins were wound with sufficient resin to create filleting in the core. The fabrication sequence is shown in Figure 11.

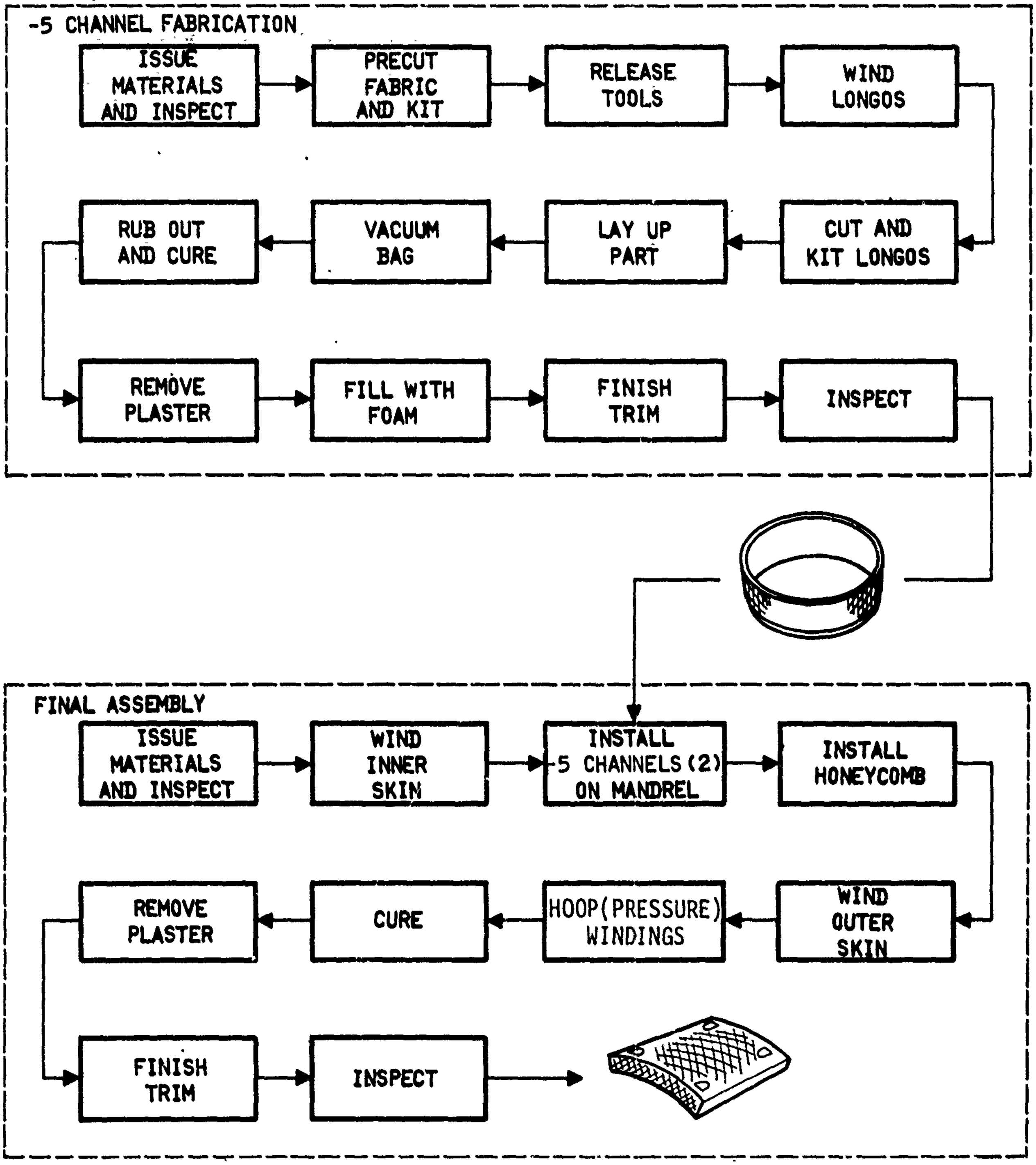


Figure 11. Manufacturing Steps: Type A

SPAR BOX-RIB JOINT (TYPE D)

The composite spar box-rib joint was designed to replace its metal equivalent in a helicopter vertical stabilizer. This joint includes a rib that secures the attach fittings and carries the shear induced by coupled applied loads from the tail rotor. In addition, corner spar caps are cocured into the sandwich box structure to carry longitudinal bending loads. The detail drawing of Joint Type D is shown in Figure 12.

DESIGN CRITERIA

Detail design of the final concept was controlled by the following criteria:

a. Loads - Critical tension and compression loads from the tail rotor strike condition that are applied to the fittings must be transferred through the rib to the box structure in shear. The rib provides stability to the metal fittings.

b. Cost - Wet filament winding was chosen as the fabrication method to minimize the cost of the spar box structure. The fitting design was simplified to minimize machining and assembly costs.

c. Environmental protection - The gearbox attach fitting includes two internal 4140 steel fittings that require a finish system for bonding and environmental protection, and the external graphite/epoxy skin of a composite vertical stabilizer spar is primed and painted, both in accordance with approved aircraft process specifications.

STRESS ANALYSIS

In the hand stress analysis of Joint Type D, the following were determined:

a. Critical loads at the tail rotor gearbox attachment fittings

b. Section properties

c. Internal forces (shear flows in spar box walls and internal ribs)

d. Shear tear-out of lug through composite skins

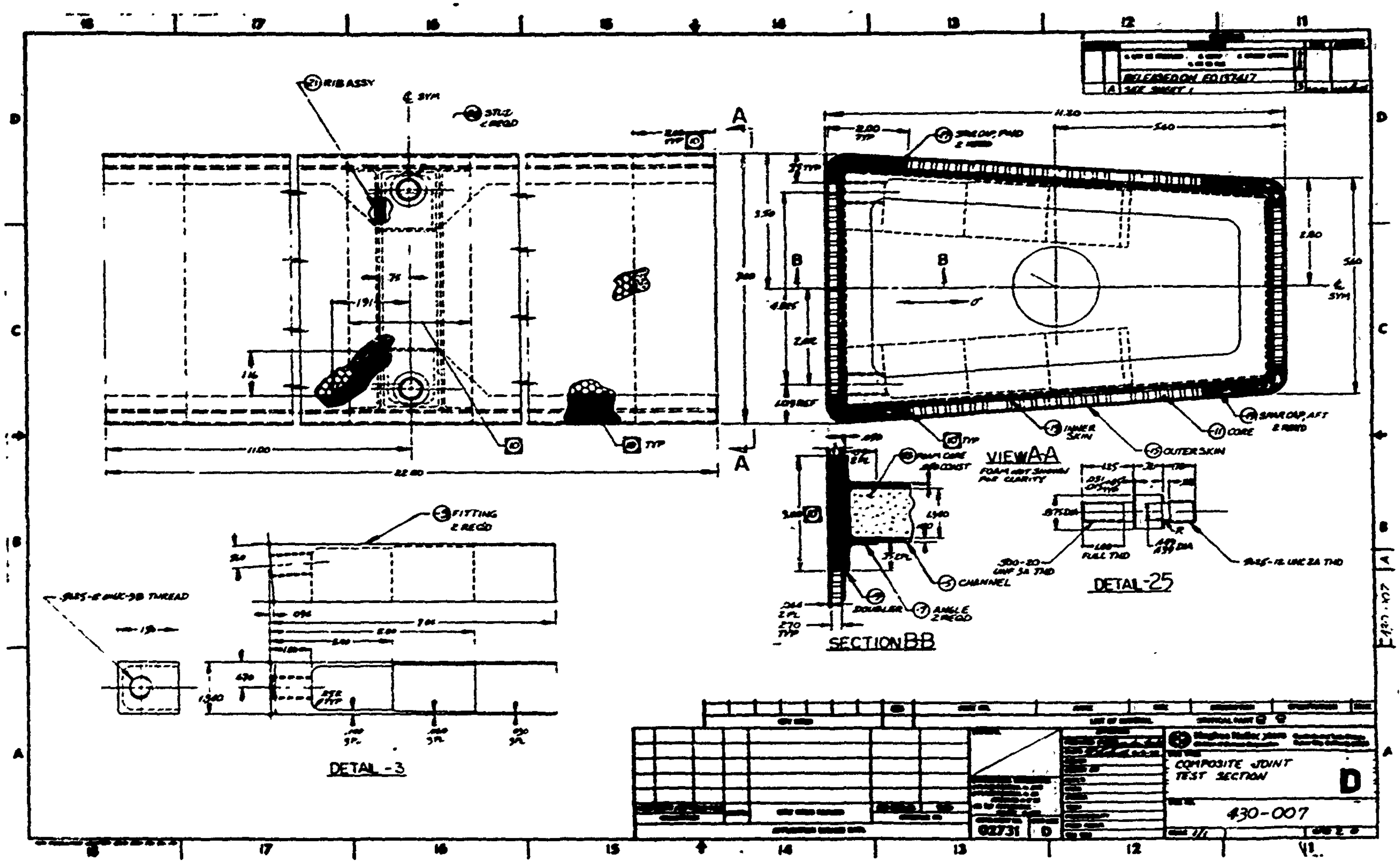


Figure 12. Final Detail Design: Type D

e. Shear between steel fitting and graphite rib

f. Rib stability

FABRICATION METHODS

Fabrication of Joint Type D simulated the methods to be used during production. The plies for the four -17 spar caps were wet filament wound on a drum mandrel, cut into patterns, and laid up on a male tool. Each part was staged under vacuum and trimmed before final assembly. The -5 internal rib was laid up with graphite fabric over a foam core and staged in a female die mold. The rib was then assembled into the spar mandrel prior to winding of the inner skin. Honeycomb core was placed on the mandrel, and then the outer skin was wound. These fabrication steps are shown in Figure 13.

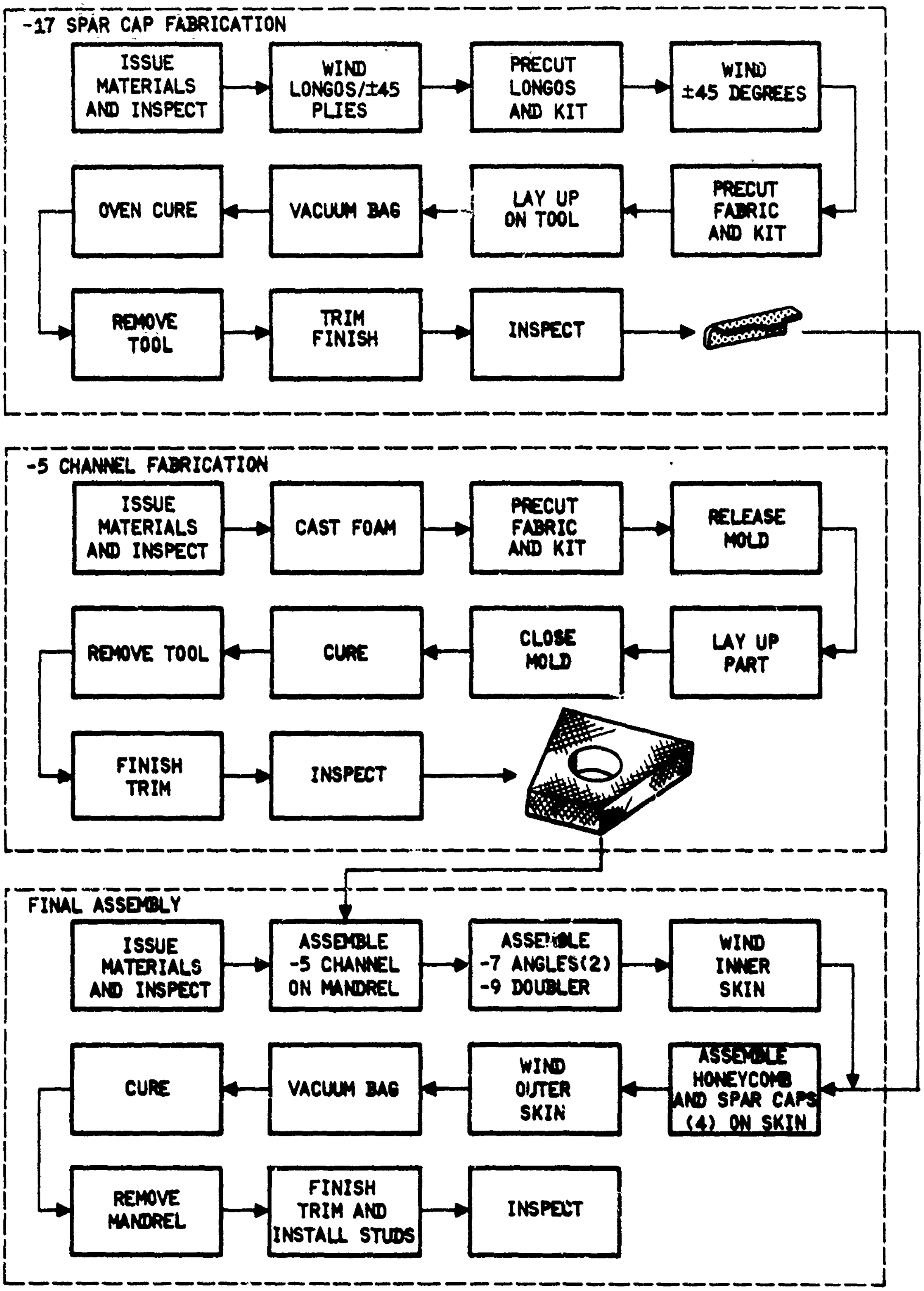


Figure 13. Manufacturing Steps: Type D

COPILOT SEAT FITTING (TYPE K)

The copilot seat fitting design, derived from the metal seat attachment fitting design, utilizes the turn-the-corner angle concept to carry (mainly) tension loads. The final design drawing is shown in Figure 14.

DESIGN CRITERIA

Detail design of the final concept was controlled by the following criteria:

a. Configuration - The substitution of composite materials for metals was the primary change in this design because the seat fitting configuration and its location could not be changed significantly. Space limitations also limited the design alternatives.

b. Loads - Interlaminar shear stress in the corner of the composite angles due to lug pullout loads was an omnipresent factor during the design phase.

c. Cost - Manual layup of fabric provided the most cost-effective fabrication technique. Wet filament winding of the plies could not be justified due to the low material requirement.

d. Environmental protection - Since the copilot seat fitting is inside the helicopter, no finish is required.

STRESS ANALYSIS

The composite layup sequence was determined by lug shearout stresses in the following stress analysis procedure:

a. Critical vertical, horizontal, and lateral applied loads

b. Internal loads and bolt reactions

c. Composite tensile stresses, allowing for bolt hole concentration factors

d. Composite angle strength (see Figure 6)

e. Lug bearing and shearout stresses

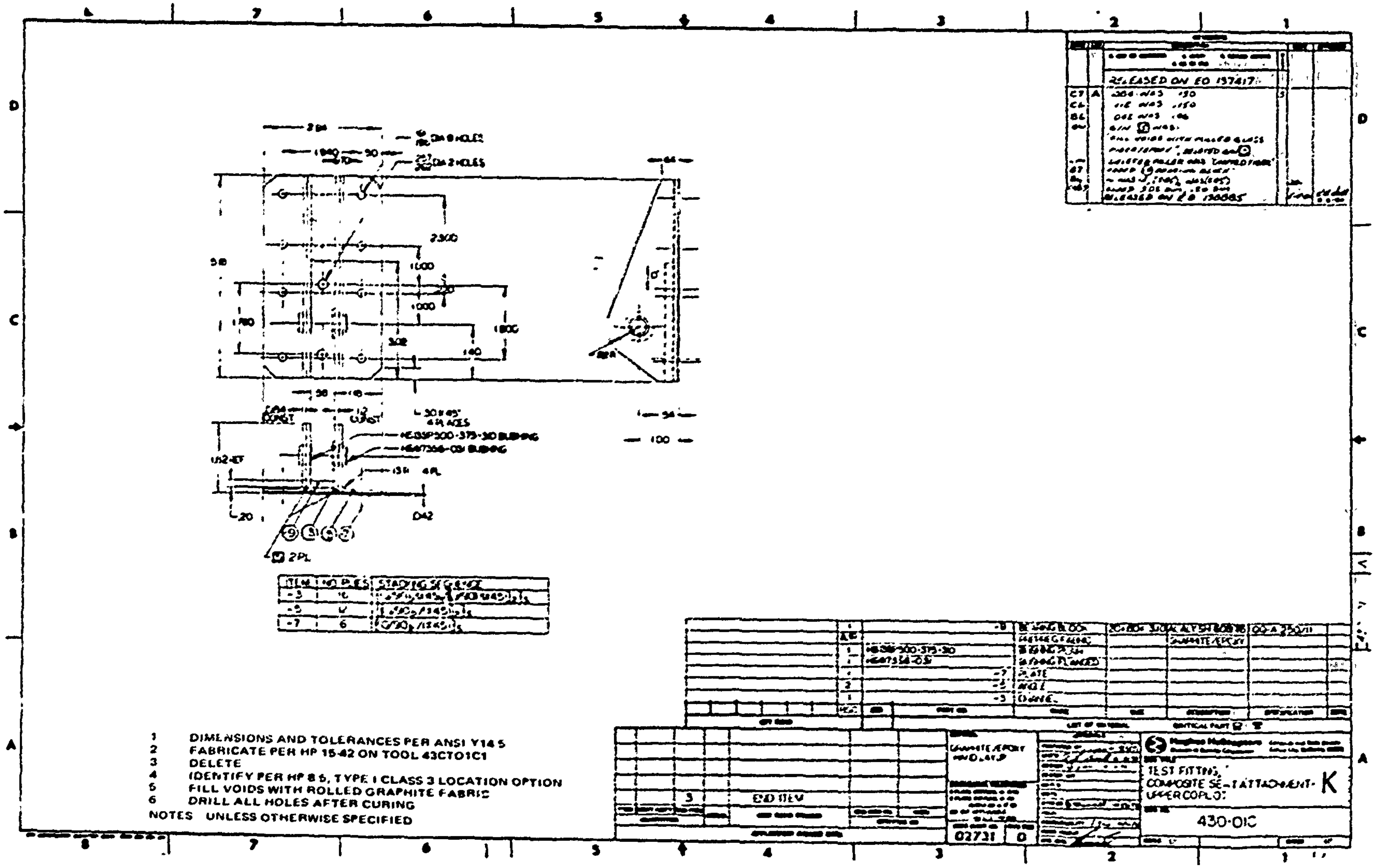


Figure 14. Final Detail Design: Type K

FABRICATION METHODS

Joint Type K was fabricated by laying up preimpregnated graphite fabric on four aluminum blocks; these were then assembled for cocuring. Three fittings were cut and trimmed from the cured assembly, and bushings were installed. The fabrication process is shown in Figure 15.

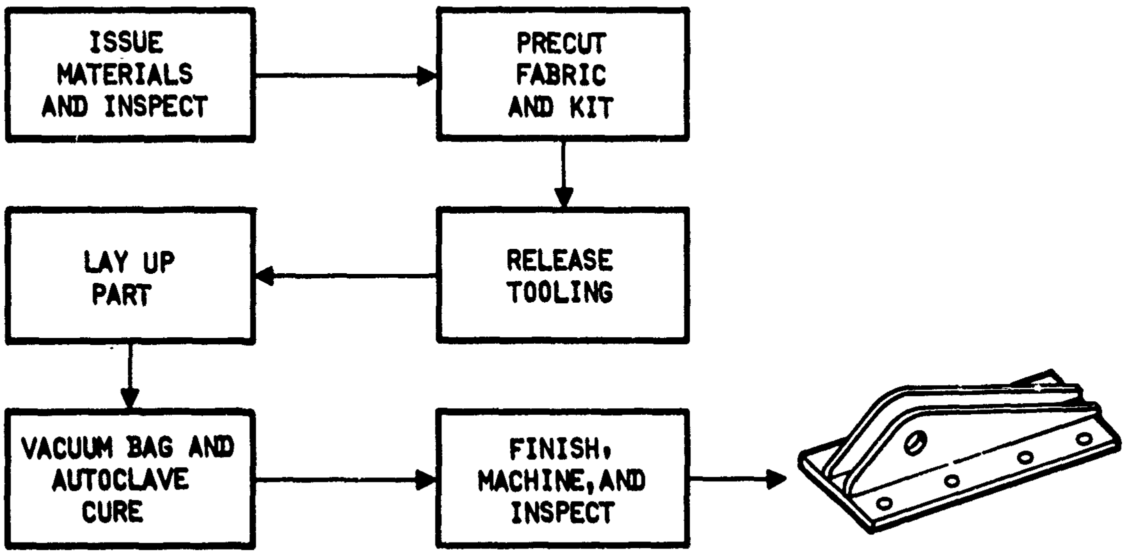


Figure 15. Manufacturing Steps: Type K

INSPECTION METHODS

In manufacturing these joints and fittings, as many components as possible are cocured during a single cycle. While this method of assembly has significant advantages from a manufacturing standpoint, it makes it impossible to individually inspect the various components that make up an assembly. The types of defects that can degrade the performance of composite structures are:

a. Delaminations

b. Unbonded areas

c. Porosity or voids

d. Resin-rich or resin-starved areas

e. Geometry of internal details

f. Thick bondlines

g. Position and bond of metal inserts

h. Foreign object inclusions

The importance of these defects varies with their size and location in relation to the size and geometry of the particular joint or fitting design in which they occur. Assurance that the finished part has been fabricated free of internal defects and has the proper internal geometry can only be obtained using nondestructive inspection techniques.

These techniques include the hammer tapping method, in which a small hammer is used to tap the surface of the composite component. The flat sound produced by tapping over an unbonded area or void is easily detected, even by an untrained ear, and an experienced inspector can readily determine and mark the boundaries of the unbonded area or void. Subsequent tapping can determine the growth of an unbonded area if it occurs.

The Shurtronics harmonic bond tester operates by physically transmitting high-frequency vibrations into bonded materials and monitoring the resulting acoustical response with a small hand-held transducer. The instrument is calibrated with a sample specimen of the same materials and layup as the part under examination, with known defects built in for reference. With the instrument calibrated for a known density and thickness, a reduction in local thickness caused by an unbonded area or other defect results in an amplitude or phase change in the received signal. Liquid coupling is not required for testing, and the probe can easily be used in any position.

The cost effectiveness of each composite fitting design was measured by considering the individual weight reductions afforded by switching to composites and the cost increments vis-a-vis the metal baseline. To differentiate between cost effective and cost ineffective designs, the cost differences and the weight reductions were plotted in Figure 16. The population of cost-vs-efficiency points is divided into two domains by the cost effectiveness break-even lines, with cost-effective designs residing above and to the left of the lines. Cost-effective designs possess features that add value (in the form of weight reduction) that more than offsets the extra expense. The slope of the break-even line is determined by the value of eliminating a pound of structure from a helicopter without altering its structural performance.

The cost of saving weight can also be portrayed by plotting part weight versus total cost (Figure 17).

The relationship between the cost and weight of composite fittings implies that the total cost per pound is $174 for Joint Type D, $329 for Type A, and $593 for Type K. The $300-per-pound line is added to the graph for comparison.

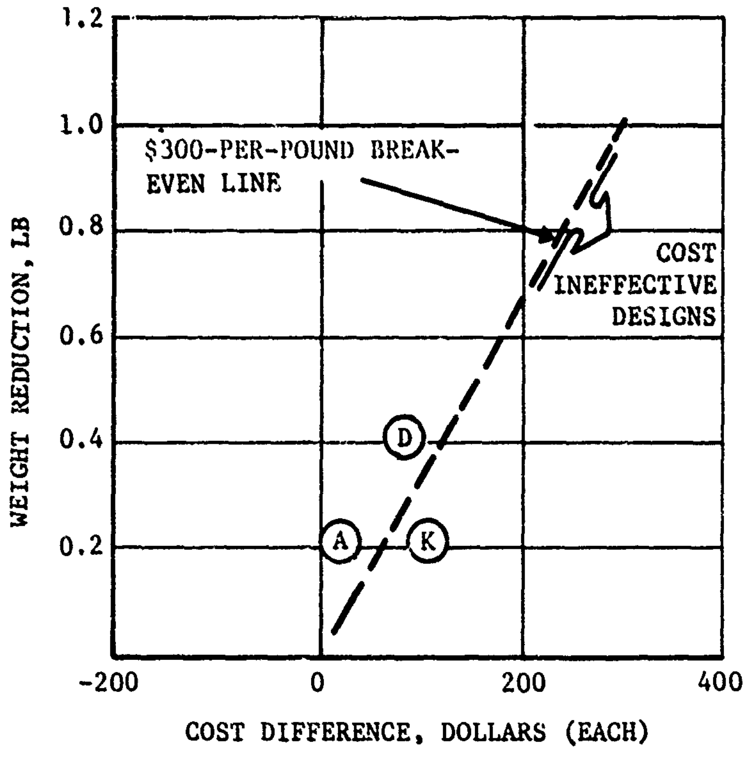


Figure 16. Break-Even Partitioning of Composite Fittings

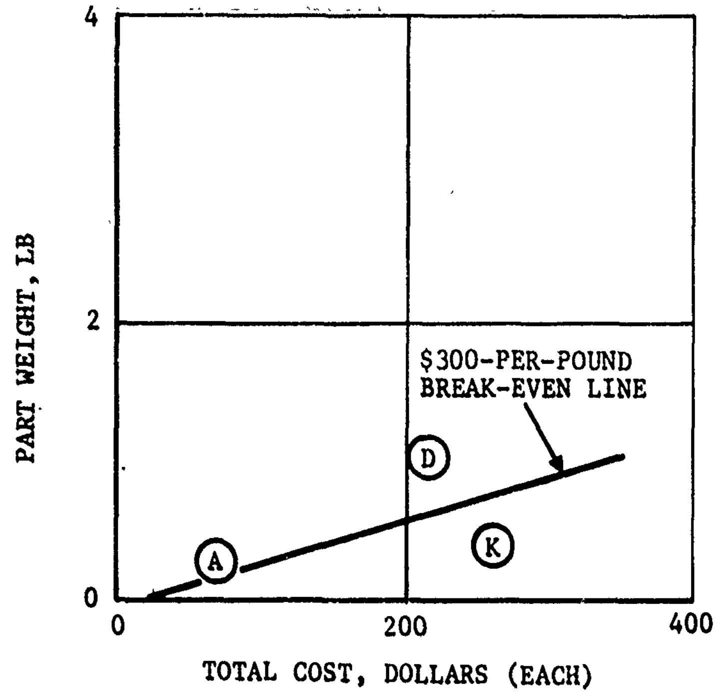


Figure 17. Cost vs Weight Relationship of Composite Fittings

FINITE ELEMENT ANALYSES

ANGLE BRACKET MODEL

Finite element models C-1 and C-2 were developed to predict the interlaminar shear present in the radius of an angle (Figure 18). Using the half-symmetrical C-1 model (Figure 19), variations in washer diameter, washer distance from the bend, lamina orientation, lamina thickness, and bend radius-to-thickness ratio can be investigated. Using the C-2 one-strip model, variations in stacking sequence can be analyzed (Figure 20).

To minimize computer costs, the analysis was conducted in two stages. The bracket was first analyzed as a single-layer (solid laminate), multistrip structure (C-1 model) to identify the critical strip and the corresponding boundary conditions. In the second stage of the analysis, the critical strip was further divided into many discrete layers (C-2 model), to represent the actual laminated structure, and analyzed in terms of the boundary conditions obtained from the C-1 model to identify interlaminar stresses.

It is possible to conduct many parametric analyses using the C-1 and C-2 models. Figure 21 shows the relationship between normalized shear stress (defined as interlaminar shear stress τ_{xy} divided by net tension stress σ_0) and the width of the angle bracket. It should be noted that, since the interlaminar shear stress in composite components ranges from 1,000 to 5,000 pounds per square inch, the net tension stress is limited to $\tau_{xy}/2.5$, or 400 to 2,000 pounds per square inch. Actual test results, however, indicate higher allowables.

INDIVIDUAL JOINT MODELS

NASTRAN models were developed for Joint Types A, D, and K. Instead of developing one three-dimensional model for each type, a pair of two-dimensional models was constructed to minimize development time. The models for Joint Types A, D, and K are shown in Figures 22 through 27. Orthotropic plates, with appropriate mechanical properties, are used in all instances.

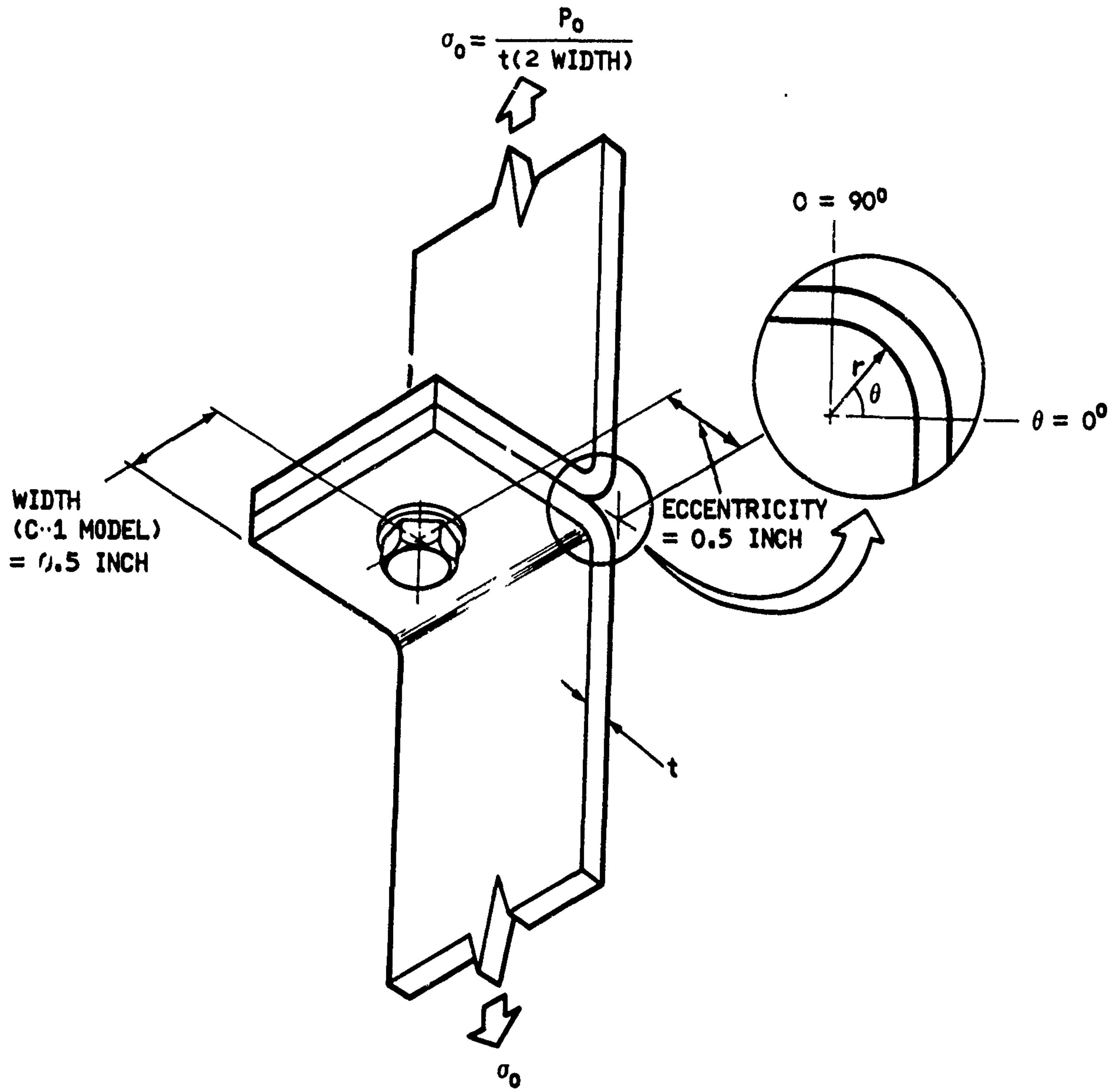


Figure 18. Typical Laminated Angle Bracket

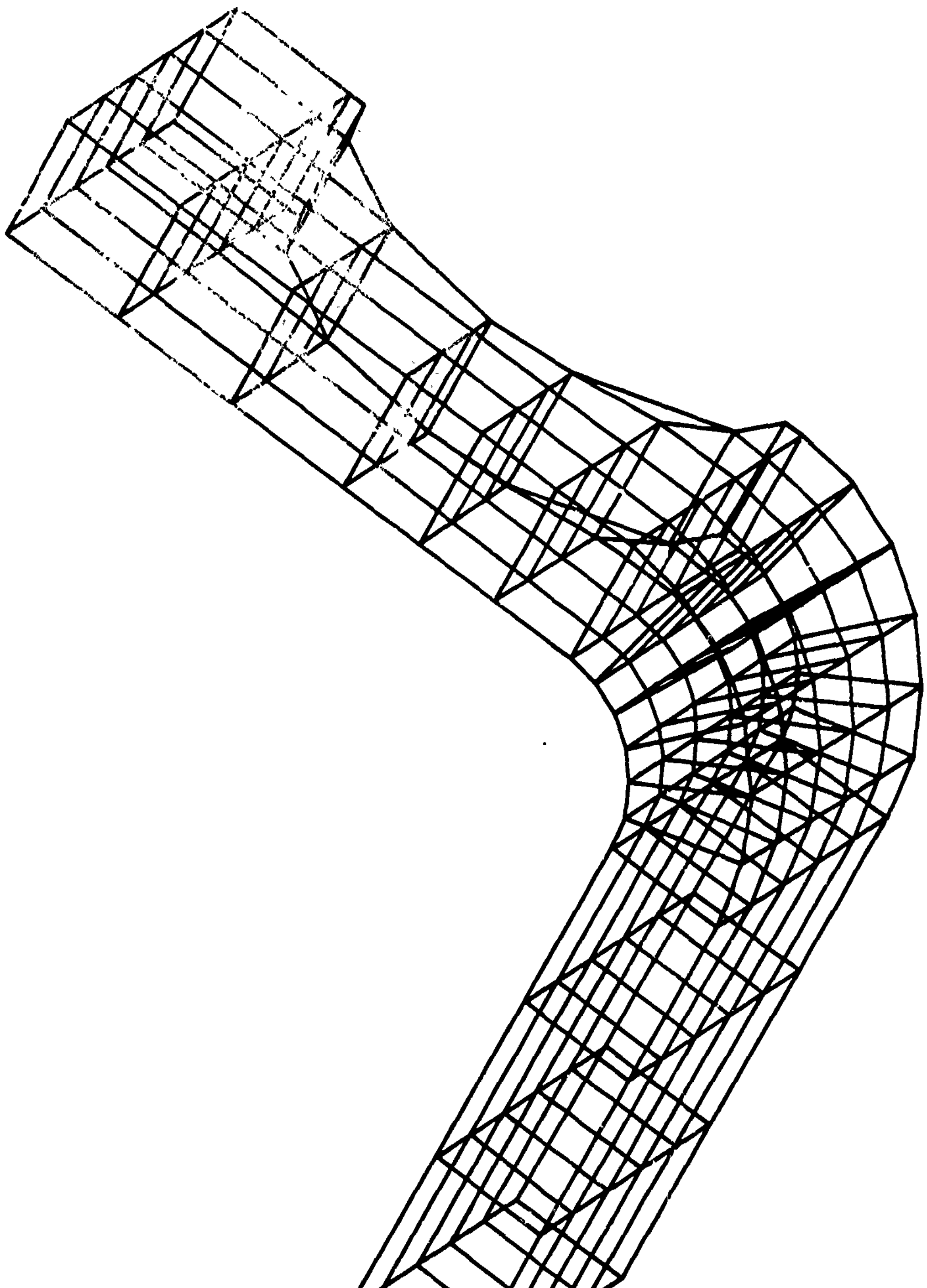


Figure 19. NASTRAN Model C-1

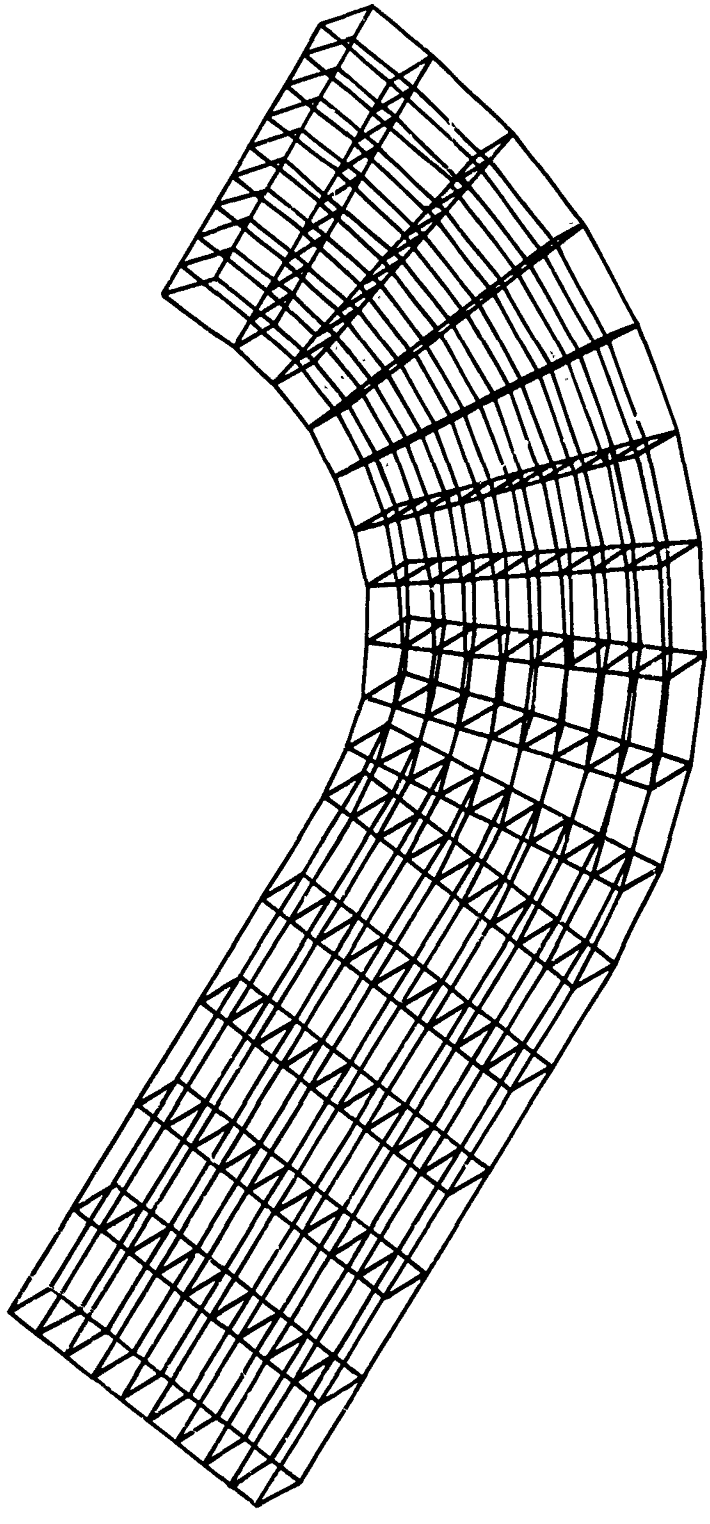
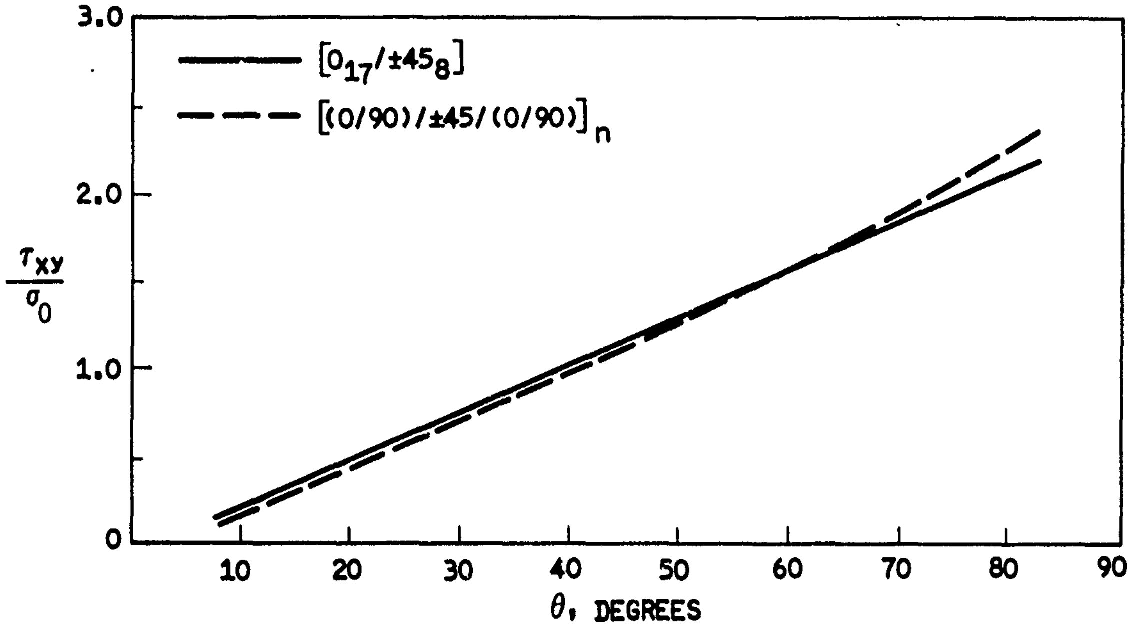


Figure 20. NASTRAN Model C-2



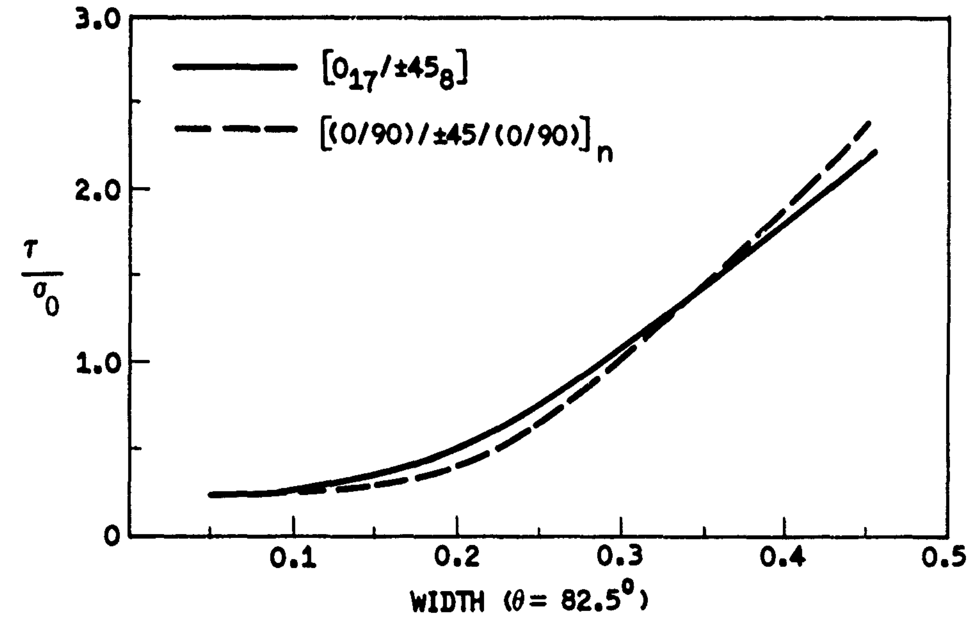


Figure 21. Normalized Shear Stress vs Bracket Angle and Width

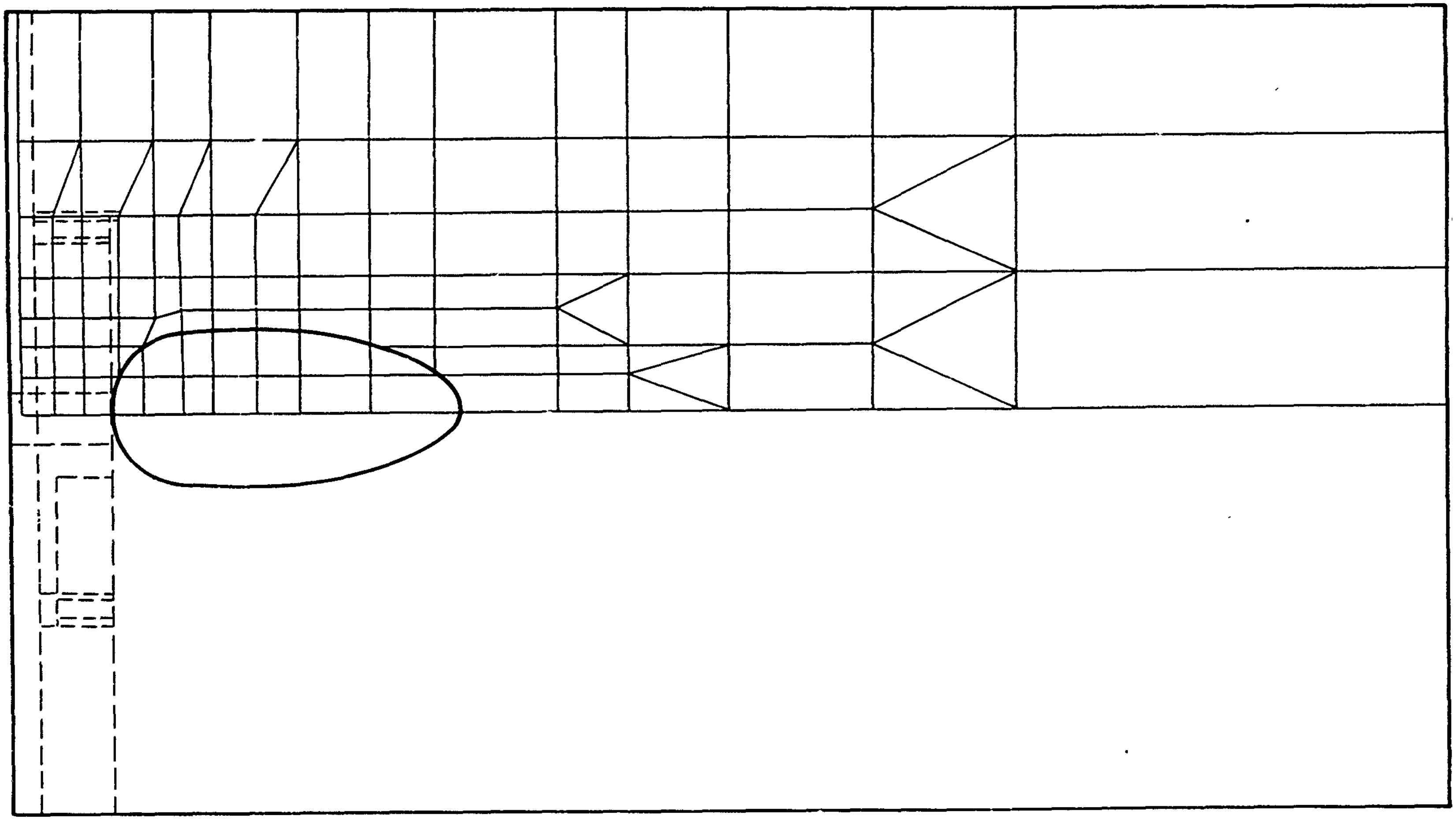
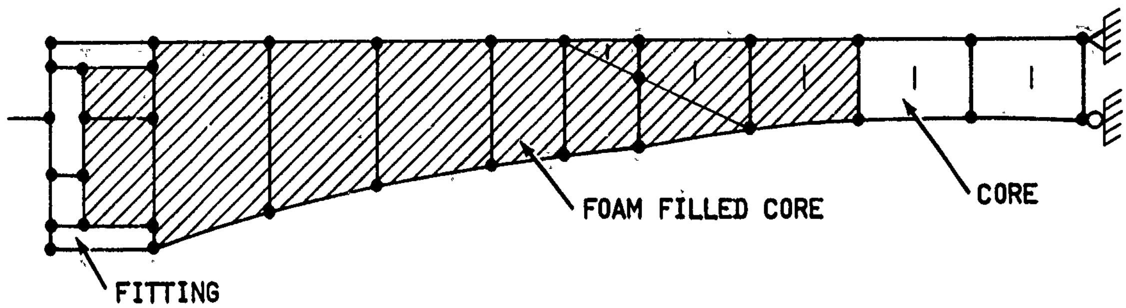
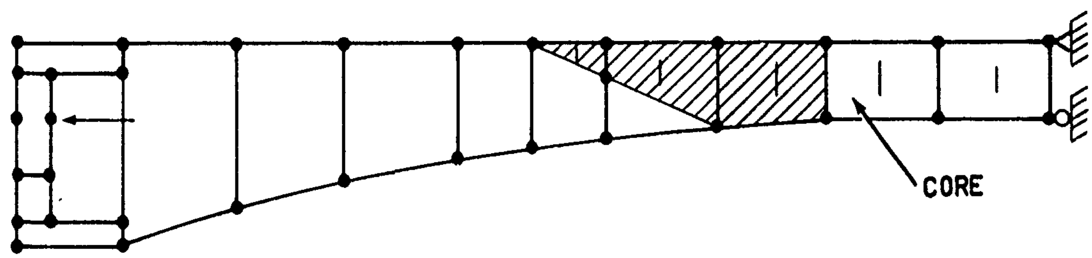


Figure 22. NASTRAN Model of Joint Type A (Top View)



SECTION B-B OF DRAWING No. 430-009 (Figure 10)



SECTION A-A OF DRAWING No. 430-009 (Figure 10)

Figure 23. NASTRAN Model of Joint Type A (Side View)

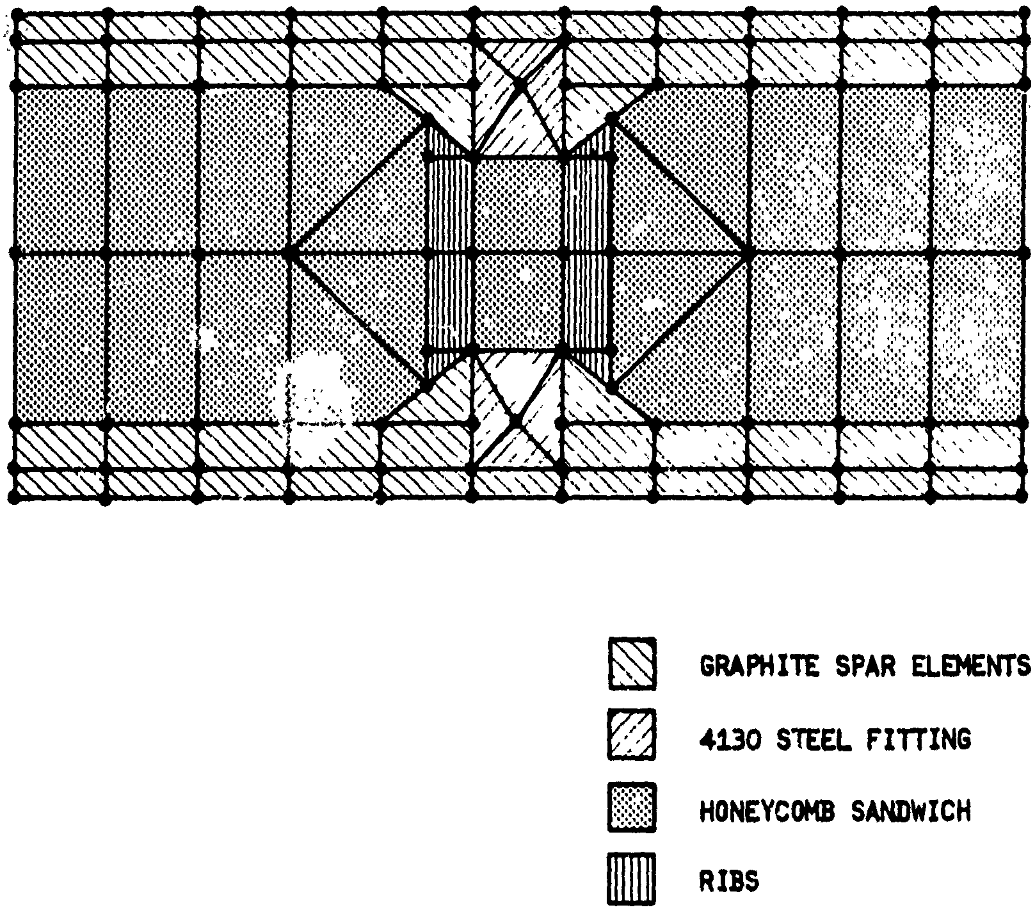


Figure 24. NASTRAN Model of Joint Type D (Top View)

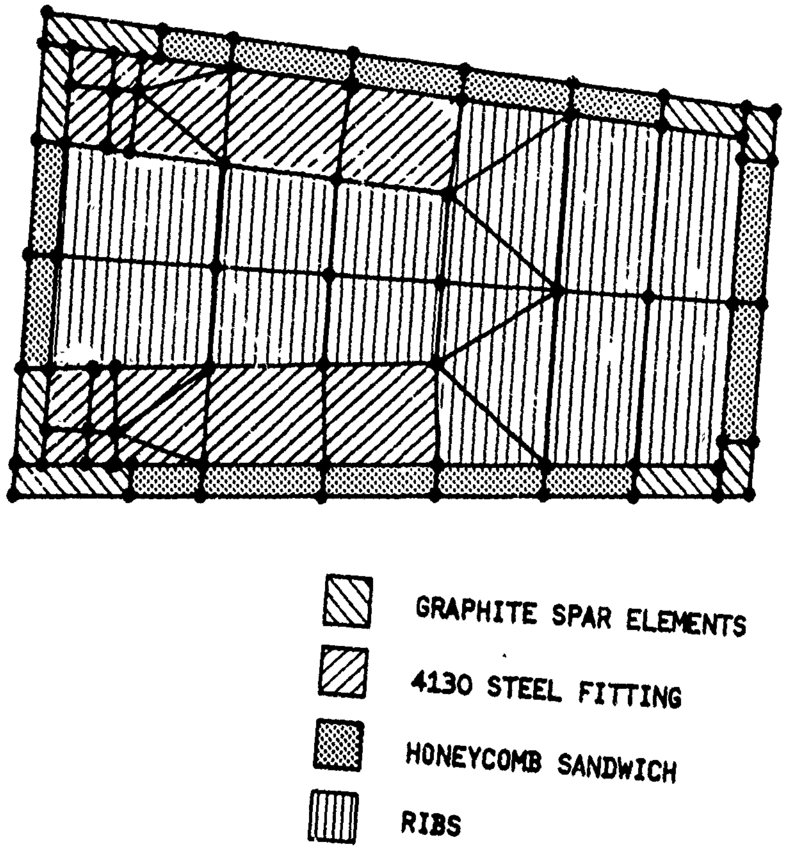


Figure 25. NASTRAN Model of Joint Type D (Side View)

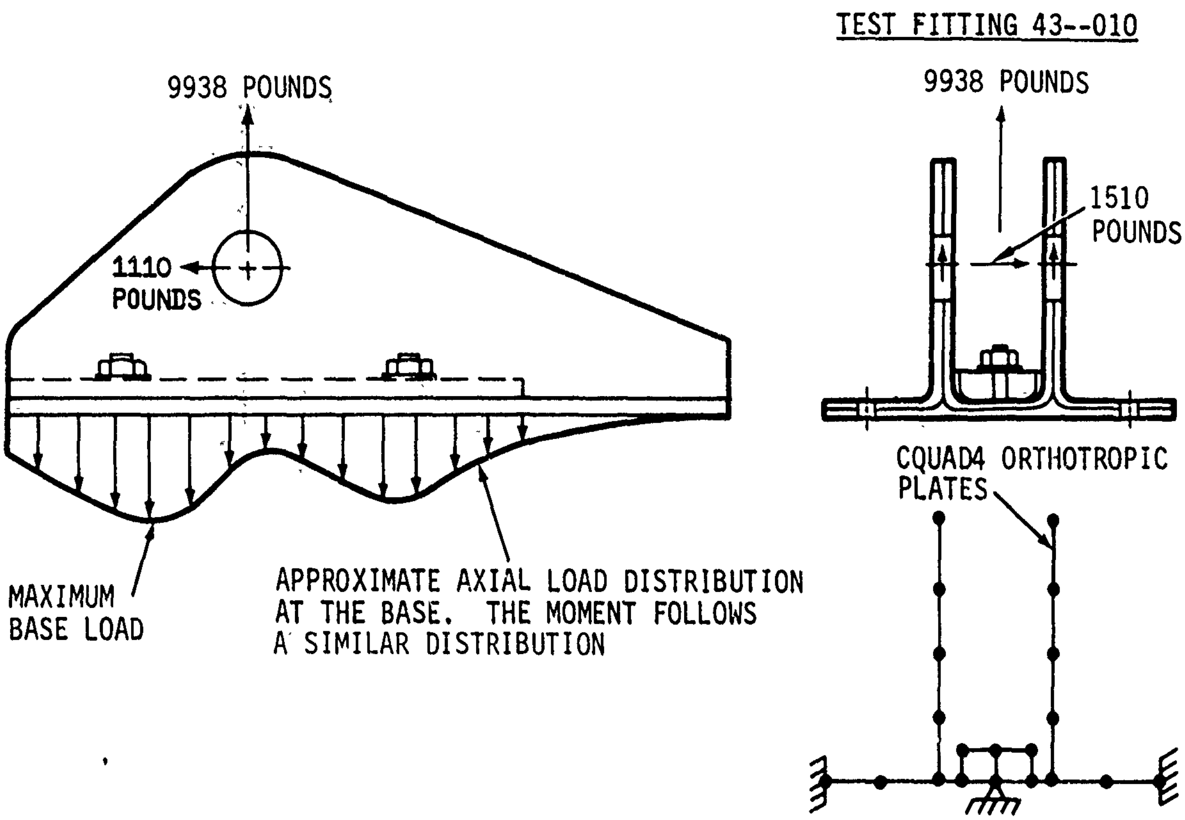


Figure 26. NASTRAN Model of Joint Type K (Front and Side Views)

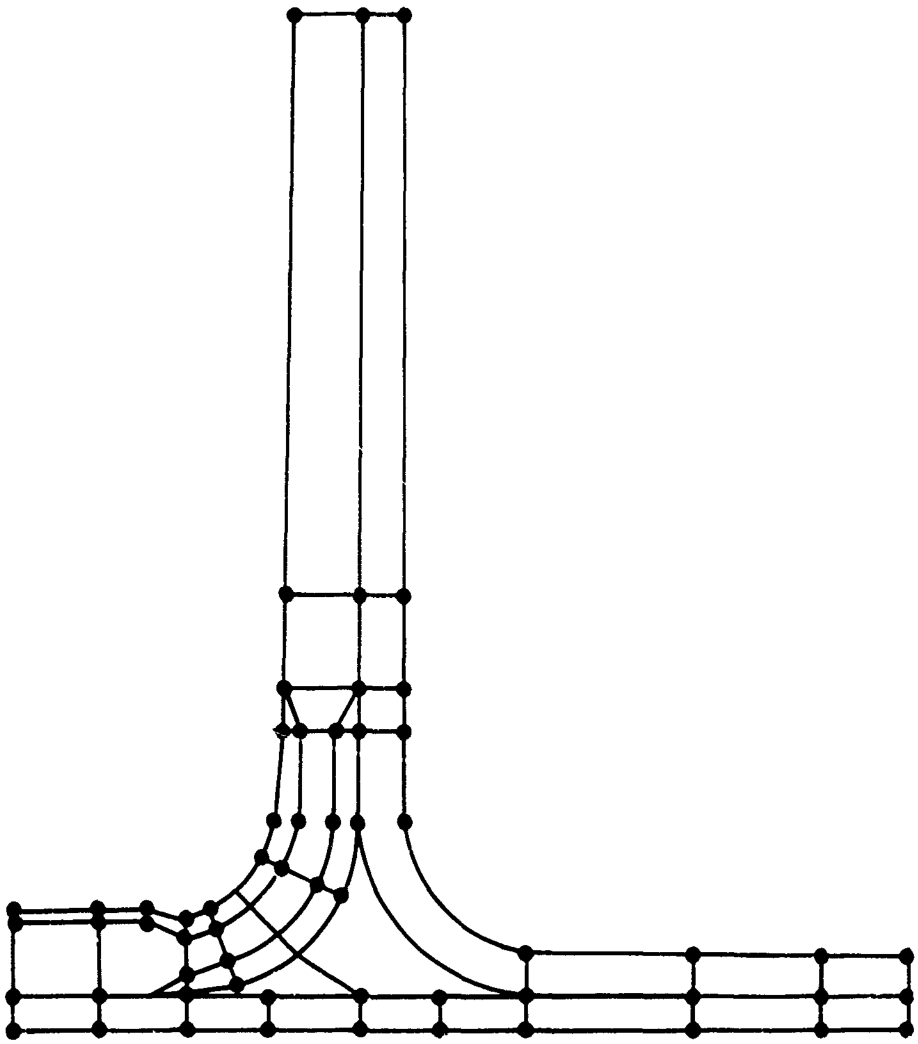


Figure 27. NASTRAN Model of Joint Type K
(Internal Loads)

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Engineering Design Handbook: Joining of Advanced Composites, DARCOM-P-706-316, U.S. Army Materiel Development and Readiness Command, Alexandria, Virginia, March 1978.

Jones, R.M., "Mechanics of Composite Materials," Scripta, Washington, D. C., 1975.

APPENDIX A

COMPOSITE MATERIAL ALLOWABLES

The graphite and Kevlar composite allowables used in the design analyses documented in this report are given in Tables A-1 through A-14. Laminate moduli, strength, and other physical property values are given as a function of fiber angle for fiber volumes of 0.55 and 0.60. Fiber, resin, and composite input data terms are defined as:

AF (AR) = Fiber (resin) coefficient of thermal expansion, in./in./°F

AFT = Fiber transverse coefficient of thermal expansion, in./in./°F

EF (ER) = Fiber (resin) elastic modulus, psi

EFT = Fiber transverse elastic modulus, psi

FCU = Fiber or composite ultimate compressive strength, psi

FSU = Resin ultimate shear strength, psi

FTU = Fiber or composite ultimate tensile strength, psi

GF = Fiber shear modulus, psi

RHO = Composite density, lb/ft^3

RHOF (RHOR) = Fiber (resin) density, lb/ft^3

UF (UR) = Fiber (resin) Poisson's ratio (dimensionless)

VF (VR) = Fiber (resin) volume, percent

WF (WR) = Fiber (resin) weight, percent

Composite properties are abbreviated as follows:

ALPHA = Fiber angle, deg

AX = Coefficient of thermal expansion, X direction, in./in./°F

AY = Coefficient of thermal expansion, Y direction, in./in./°F

EX = Elastic modulus, X direction, psi

EY = Elastic modulus, Y direction, psi

FXCU = Ultimate compressive strength, X direction, psi

FXTU = Ultimate tensile strength, X direction, psi

FXY = Ultimate shear strength, psi

FYCU = Ultimate compressive strength, Y direction, psi

FYTU = Ultimate tensile strength, Y direction, psi

GXY = Shear modulus, psi

UXY = Poisson's ratio, perpendicular to X direction (dimensionless)

UYX = Poisson's ratio, perpendicular to Y direction (dimensionless)

TABLE A-1. GRAPHITE COMPOSITE PROPERTIES

FIBER PROPERTIES		RESIN PROPERTIES		COMPOSITE PROPERTIES
VF = 0.5500	EF = 3.400E+07	VR = 0.4500	ER = 4.700E+05	RHO = 0.0535
WF = 0.6536	EFT = 1.300E+06	WR = 0.3464	AR = 4.000E-05	FTU = 178750.0
RHOF = 0.0636	GF = 3.500E+06	RHOF = 0.0412	UR = 0.3500	FCU = 118250.0
FTU = 325000.0	AF = -2.400E-07	FSU = 8000.0		FSU = 8000.0
FCU = 215000.0	AFT = 2.960E-06			
UF = 0.2200				
FIBER PROPERTIES		**RESIN PROPERTIES**		**COMPOSITE PROPERTIES**
VF = 0.6000	EF = 3.400E+07	VR = 0.4000	ER = 4.700E+05	RHO = 0.0546
WF = 0.6984	EFT = 1.300E+06	WR = 0.3016	AR = 4.000E-05	FTU = 195000.0
RHOF = 0.0636	GF = 3.500E+06	RHOF = 0.0412	UR = 0.3500	FCU = 129000.0
FTU = 325000.0	AF = -2.400E-07	FSU = 8000.0		FSU = 8000.0
FCU = 215000.0	AFT = 2.960E-06			
UF = 0.2288				

TABLE A-2. GRAPHITE MODULI (VF = 0.55)

ALPHA	EX	EY	GXY
0.00	1.891E+07	9.108E+05	5.665E+05
1.00	1.890E+07	9.107E+05	5.717E+05
2.00	1.886E+07	9.111E+05	5.873E+05
3.00	1.879E+07	9.119E+05	6.133E+05
4.00	1.869E+07	9.129E+05	6.494E+05
5.00	1.856E+07	9.143E+05	6.956E+05
6.00	1.839E+07	9.160E+05	7.515E+05
7.00	1.819E+07	9.180E+05	8.170E+05
8.00	1.795E+07	9.204E+05	8.917E+05
9.00	1.767E+07	9.231E+05	9.753E+05
10.00	1.734E+07	9.263E+05	1.067E+06
11.00	1.697E+07	9.299E+05	1.167E+06
12.00	1.655E+07	9.339E+05	1.275E+06
13.00	1.609E+07	9.385E+05	1.389E+06
14.00	1.559E+07	9.435E+05	1.510E+06
15.00	1.504E+07	9.492E+05	1.637E+06
16.00	1.445E+07	9.555E+05	1.769E+06
17.00	1.383E+07	9.624E+05	1.905E+06
18.00	1.319E+07	9.701E+05	2.045E+06
19.00	1.253E+07	9.786E+05	2.189E+06
20.00	1.185E+07	9.880E+05	2.335E+06
21.00	1.117E+07	9.984E+05	2.483E+06
22.00	1.049E+07	1.010E+06	2.632E+06
23.00	9.826E+06	1.022E+06	2.781E+06
24.00	9.175E+06	1.036E+06	2.930E+06
25.00	8.547E+06	1.051E+06	3.078E+06
26.00	7.844E+06	1.068E+06	3.224E+06
27.00	7.371E+06	1.087E+06	3.388E+06
28.00	6.830E+06	1.107E+06	3.508E+06
29.00	6.323E+06	1.130E+06	3.645E+06
30.00	5.849E+06	1.154E+06	3.777E+06
31.00	5.410E+06	1.181E+06	3.903E+06
32.00	5.004E+06	1.211E+06	4.024E+06
33.00	4.630E+06	1.244E+06	4.139E+06
34.00	4.286E+06	1.281E+06	4.246E+06
35.00	3.972E+06	1.321E+06	4.346E+06
36.00	3.685E+06	1.365E+06	4.438E+06
37.00	3.424E+06	1.414E+06	4.522E+06
38.00	3.187E+06	1.468E+06	4.596E+06
39.00	2.971F+06	1.527E+06	4.662E+06
40.00	2.775E+06	1.593E+06	4.718E+06
41.00	2.697E+06	1.665E+06	4.764E+06
42.00	2.436E+06	1.745E+06	4.800E+06
43.00	2.291E+06	1.834E+06	4.826E+06
44.00	2.159E+06	1.932E+06	4.842E+06
45.00	2.039E+06	2.048E+06	4.847E+06

TABLE A-3. GRAPHITE MODULI (VF = 0.60)

ALPHA	EX	EY	GXY
0.00	2.059E+07	9.451E+05	6.343E+05
1.00	2.057E+07	9.453E+05	6.400E+05
2.00	2.053E+07	9.439E+05	6.569E+05
3.00	2.045E+07	9.470E+05	6.850E+05
4.00	2.035E+07	9.485E+05	7.242E+05
5.00	2.020E+07	9.504E+05	7.742E+05
6.00	2.002E+07	9.528E+05	8.348E+05
7.00	1.980E+07	9.556E+05	9.058E+05
8.00	1.954E+07	9.590E+05	9.887E+05
9.00	1.924E+07	9.628E+05	1.077E+06
10.00	1.838E+07	9.672E+05	1.177E+06
11.00	1.848E+07	9.722E+05	1.205E+06
12.00	1.802E+07	9.778E+05	1.402E+06
13.00	1.752E+07	9.840E+05	1.526E+06
14.00	1.698E+07	9.989E+05	1.657E+06
15.00	1.637E+07	9.985E+05	1.794E+06
16.00	1.573E+07	1.002E+06	1.937E+06
17.00	1.906E+07	1.016E+06	2.065E+06
18.00	1.435E+07	1.026E+06	2.237E+06
19.00	1.363E+07	1.038E+06	2.392E+06
20.00	1.290E+07	1.058E+06	2.551E+06
21.00	1.216E+07	1.063E+06	2.711E+06
22.00	1.143E+07	1.078E+06	2.873E+06
23.00	1.071E+07	1.094E+06	3.834E+06
24.00	1.001E+07	1.112E+06	3.196E+06
25.00	9.332E+06	1.131E+06	3.356E+06
26.00	8.687E+06	1.152E+06	3.515E+06
27.00	8.066E+06	1.175E+06	3.670E+06
28.00	7.484E+06	1.200E+06	3.822E+06
29.00	6.937E+06	1.227E+06	3.970E+06
30.00	6.427E+06	1.257E+06	4.113E+06
31.00	5.957E+06	1.290E+06	4.250E+06
32.00	5.514E+06	1.326E+06	4.381E+06
33.00	5.110E+06	1.366E+06	4.505E+06
34.00	4.778E+06	1.409E+06	4.622E+06
35.00	4.398E+06	1.456E+06	4.738E+06
36.00	4.086E+06	1.508E+06	4.830E+06
37.00	3.801E+06	1.565E+06	4.920E+06
38.00	3.542E+06	1.627E+06	5.001E+06
39.00	3.306E+06	1.696E+06	5.072E+06
40.00	3.091E+06	1.771E+06	5.133E+06
41.00	2.895E+06	1.854E+06	5.183E+06
42.00	2.718E+06	1.845E+06	5.222E+06
43.00	2.556E+06	2.045E+06	5.250E+06
44.00	2.409E+06	2.155E+06	5.267E+06
45.00	2.276E+06	2.276E+06	5.273E+06

TABLE A-4 GRAPHITE STRENGTH ALLOWABLES (VF = 0.55)

ALPHA	FXTU	FYTU	FXCU	FYCU	FXY
0.00	178750.0	0.0	118250.0	5673.3	4408.0
1.00	178296.6	6.5	118173.7	5674.2	4676.8
2.00	176949.2	26.1	117942.9	5677.0	4968.8
3.00	174744.6	58.8	117551.5	5681.7	5286.4
4.00	171741.7	104.7	116990.0	5688.4	5631.7
5.00	168017.3	163.8	116245.3	5697.1	6007.3
6.00	183661.7	236.3	115301.9	5707.8	6415.6
7.00	158773.6	322.3	114142.1	5720.7	6859.3
8.00	153454.8	422.1	112747.4	5735.9	7341.1
9.00	147806.4	535.7	111099.6	5753.5	7863.5
10.00	141924.5	663.5	109182.3	5773.6	8429.4
11.00	135898.0	805.6	106982.1	5796.4	9041.2
12.00	129806.1	962.5	104490.5	5822.2	9701.4
13.00	123718.0	1134.4	101705.1	5851.1	10412.3
14.00	117691.9	1321.7	98630.9	5883.3	11175.9
15.00	111775.8	1524.7	95281.4	5919.2	11993.7
16.00	106807.8	1744.0	91678.4	5959.1	12866.8
17.00	100417.4	1979.9	87852.4	6003.3	13796.0
18.00	95025.9	2233.0	83841.0	6052.2	14780.9
19.00	89848.3	2503.9	79688.1	6106.3	15820.9
20.00	84893.6	2793.2	75441.5	6165.9	16914.2
21.00	80166.4	3101.4	71150.6	6231.6	18058.1
22.00	75667.3	3429.3	66864.8	6304.1	19248.9
23.00	71394.2	3777.7	62630.6	6383.9	20481.8
24.00	67342.5	4147.4	58490.4	6471.8	21750.9
25.00	63505.9	4539.2	54480.7	6568.6	23049.1
26.00	59877.0	4954.1	50631.9	6675.1	24368.6
27.00	56447.3	5393.0	46967.4	6792.4	25700.1
28.00	53208.2	5857.2	43504.1	6921.5	27033.9
29.00	50150.4	6347.6	40252.5	7063.7	28359.4
30.00	47264.6	6865.6	37217.8	7220.2	29665.7
41.00	44541.9	7412.5	34400.0	7392.7	30941.7
32.00	41973.1	7989.7	31795.8	7582.6	32176.2
33.00	39549.6	8598.7	29398.5	7792.0	33358.7
34.00	37262.9	9241.3	27199.2	8022.7	34479.0
35.00	35105.2	9919.1	25187.4	8277.1	35527.9
36.00	33068.6	10634.0	23351.6	8557.8	36497.2
37.00	31146.0	11388.1	21680.0	8867.4	37379.6
38.00	29330.5	12183.6	20160.5	9209.2	38169.2
39.00	27615.7	13022.7	18781.1	9586.5	38861.1
40.00	25995.5	13908.0	17530.3	10003.3	39451.7
41.00	24464.1	14842.1	16397.0	10463.7	39937.9
42.00	23016.3	15828.0	15371.0	10972.5	40317.8
43.00	21647.1	16868.7	14442.5	11534.9	40590.0
44.00	20351.8	17967.5	13602.5	12156.5	40753.6
45.00	19126.0	19127.9	12842.7	12843.9	40808.2

TABLE A-5. GRAPHITE STRENGTH ALLOWABLES (VF = 0.60)

ALPHA	FXTU	FYTU	FXCU	FYCU	FXY
0.00	195000.0	0.0	129000.0	5902.6	4928.4
1.00	194519.1	7.3	128917.1	5903.9	5228.6
2.00	193089.4	29.3	128666.3	5907.9	5554.8
3.00	190748.9	68.0	128240.7	5914.6	5906.8
4.00	187558.2	117.4	127629.4	5924.0	6289.6
5.00	183597.0	183.8	126617.8	5936.3	6704.9
6.00	178958.5	265.1	125788.1	5951.4	7155.5
7.00	173745.4	361.6	124520.7	5969.5	7644.1
8.00	163264.0	473.5	122994.9	5990.7	8173.6
9.00	162020.2	601.6	121190.4	6015.1	8746.9
10.00	155715.4	744.3	119089.3	6043.0	9366.8
11.00	149243.4	903.6	116677.2	6074.5	10036.2
12.00	142688.9	1079.8	113945.3	6109.8	10757.9
13.00	136125.9	1272.5	110892.0	6149.2	11534.1
14.00	129617.5	1482.6	107524.1	6192.9	12367.2
15.00	123216.8	1710.3	103857.6	6241.3	13259.0
16.00	116963.3	1956.2	99918.1	6294.6	14210.7
17.00	118892.3	2220.7	95740.1	6353.4	15223.2
18.00	105027.2	2504.5	91366.3	6418.0	16296.3
19.00	99385.5	2808.2	86845.3	6488.8	17429.2
20.00	93978.6	3132.5	82229.6	6566.5	18620.1
21.00	88811.0	3478.0	77573.4	6651.6	19866.2
22.00	83886.2	3845.6	72929.5	6744.6	21163.2
23.00	79202.2	4236.0	68348.0	6846.4	22506.2
24.00	74755.1	4650.3	63873.5	6957.8	23888.4
25.00	70538.9	5089.3	59544.5	7079.5	25302.2
26.00	66546.1	5554.0	55392.2	7212.6	26738.6
27.00	62768.5	6045.7	51440.8	7358.2	28187.7
28.00	59196.9	6565.5	47707.1	7517.3	29638.5
29.00	55821.9	7114.7	44201.3	7691.4	31079.4
30.00	52633.8	7694.7	40928.2	7881.8	32498.3
31.00	49623.1	8306.9	37887.1	8090.2	33883.0
32.00	46780.3	8952.9	35073.8	8318.4	35221.3
33.00	44096.2	9634.5	32480.9	8568.3	36501.7
34.00	41561.7	10353.3	30098.6	8842.1	37713.1
35.00	39168.4	11111.5	27915.6	9142.2	38845.8
36.00	36908.0	11911.1	25919.7	9471.4	39890.9
37.00	34772.8	12754.2	24098.1	9832.6	40841.1
38.00	32755.4	13643.3	22438.2	10229.1	41690.1
39.00	30848.7	14581.1	20927.3	10664.6	42433.1
40.00	29046.2	15570.1	19553.3	11143.2	43066.4
41.00	27341.8	16613.4	18304.6	11669.3	43587.2
42.00	25729.7	17714.1	17170.2	12247.9	43993.8
43.00	24204.3	18875.7	16140.1	12884.6	44284.9
44.00	22760.6	20101.7	15204.8	13585.3	44459.7
45.00	21393.9	21396.1	14355.4	14356.7	44518.0

TABLE A-6. GRAPHITE POISSON'S RATIO AND THERMAL EXPANSION (VF = 0.55)

ALPHA	UXY	UYX	AX	AY
0.00	0.2785	0.0134	2.100E-07	1.716E-05
1.00	0.2841	0.0137	2.055E-07	1.716E-05
2.00	0.3009	0.0145	1.919E-07	1.713E-05
3.00	0.3287	0.0160	1.692E-07	1.709E-05
4.00	0.3872	0.0179	1.377E-07	1.704E-05
5.00	0.4160	0.205	9.739E-08	1.696E-05
6.00	0.4745	0.0236	4.847E-08	1.687E-05
7.00	0.5420	0.0274	-8.815E-09	1.677E-05
8.00	0.6176	0.0317	-7.420E-08	1.664E-05
9.00	0.7001	0.0366	-1.474E-07	1.650E-05
10.00	0.7883	0.0421	-2.279E-07	1.635E-05
11.00	0.8806	0.0483	-3.154E-07	1.617E-05
12.00	0.9754	0.0550	-4.094E-07	1.598E-05
13.00	1.0709	0.0625	-5.093E-07	1.576E-05
14.00	1.1663	0.0785	-6.143E-07	1.553E-05
15.00	1.2569	0.0793	-7.239E-07	1.528E-05
16.00	1.3427	0.0888	-8.371E-07	1.502E-05
17.00	1.4223	0.989	-9.531E-07	1.473E-05
18.00	1.4936	0.1099	-1.071E-06	1.442E-05
19.00	1.5554	0.1215	-1.189E-06	1.409E-05
20.00	1.6068	0.1340	-1.307E-06	1.374E-05
21.00	1.6472	0.1472	-1.423E-06	1.337E-05
22.00	1.6762	0.1613	-1.535E-06	1.298E-05
23.00	1.6941	0.1763	-1.643E-06	1.257E-05
24.00	1.7011	0.1921	-1.744E-06	1.214E-05
25.00	1.6978	0.2089	-1.836E-06	1.169E-05
26.00	1.6852	0.2266	-1.918E-06	1.122E-05
27.00	1.6640	0.2453	-1.988E-06	1.074E-05
28.00	1.6354	0.2651	-2.043E-06	1.023E-05
29.00	1.6004	0.2859	-2.082E-06	9.711E-06
30.00	1.5601	0.3078	-2.103E-06	9.176E-06
31.00	1.5154	0.3309	-2.102E-06	8.627E-06
32.00	1.4572	0.3552	-2.079E-06	8.068E-06
33.00	1.4165	0.3808	-2.031E-06	7.499E-06
34.00	1.3640	0.4076	-1.956E-06	6.923E-06
35.00	1.3103	0.4357	-1.852E-06	6.343E-06
36.00	1.2561	0.4653	-1.718E-06	5.761E-06
37.00	1.2017	0.4962	-1.553E-06	5.181E-06
38.00	1.1477	0.5287	-1.354E-06	4.605E-06
39.00	1.0944	0.5627	-1.122E-06	4.037E-06
40.00	1.0428	0.5982	-8.562E-07	3.480E-06
41.00	0.9907	0.6353	-5.562E-07	2.938E-06
42.00	0.9408	0.6740	-2.227E-07	2.412E-06
43.00	0.3923	0.7144	1.437E-07	1.907E-06
44.00	0.0454	0.7564	5.417E-07	1.425E-06
45.00	0.8001	0.8001	9.698E-07	9.691E-07

TABLE A-7. GRAPHITE POISSON'S RATIO AND THERMAL EXPANSION (VF = 0.60)

ALPHA	UXY	UYX	AX	AY
0.00	0.2720	0.0125	1.275E-07	1.575E-05
1.00	0.2779	0.0128	1.233E-07	1.574E-05
2.00	0.2954	0.0136	1.106E-07	1.572E-05
3.00	0.3243	0.0150	9.004E-08	1.568E-05
4.00	0.3844	0.0170	6.113E-08	1.562E-05
5.00	0.4152	0.0195	2.421E-08	1.554E-05
6.00	0.4760	0.0226	-2.052E-08	1.545E-05
7.00	0.5460	0.0263	-7.283E-08	1.534E-05
8.00	0.6243	0.0306	-1.324E-07	1.521E-05
9.00	0.7098	0.0355	-1.990E-07	1.507E-05
10.00	0.8005	0.0410	-2.721E-07	1.491E-05
11.00	0.8954	0.0471	-3.513E-07	1.473E-05
12.00	0.9926	0.0539	-4.361E-07	1.453E-05
13.00	1.0901	0.0612	-5.260E-07	1.432E-05
14.00	1.1059	0.0693	-6.202E-07	1.409E-05
15.00	1.2732	0.0780	-7.181E-07	1.384E-05
16.00	1.3649	0.0874	-8.188E-07	1.357E-05
17.00	1.4444	0.0975	-9.215E-07	1.328E-05
18.00	1.5151	0.1083	-1.025E-06	1.298E-05
19.00	1.5759	0.1199	-1.129E-06	1.265E-05
20.00	1.6257	0.1323	-1.232E-06	1.231E-05
21.00	1.6642	0.1455	-1.332E-06	1.195E-05
22.00	1.6912	0.1595	-1.429E-06	1.158E-05
23.00	1.7868	0.1743	-1.520E-06	1.118E-05
24.00	1.7115	0.1901	-1.605E-06	1.077E-05
25.00	1.7059	0.2067	-1.683E-06	1.035E-05
26.00	1.6911	0.2243	-1.750E-06	9.905E-06
27.00	1.6679	0.2429	-1.806E-06	9.449E-06
28.00	1.6374	0.2625	-1.850E-06	8.981E-06
29.00	1.6007	0.2832	-1.878E-06	8.501E-06
30.00	1.5589	0.3050	-1.890E-06	8.010E-06
31.00	1.5129	0.3279	-1.884E-06	7.511E-06
32.00	1.4637	0.3520	-1.858E-06	7.005E-06
33.00	1.4121	0.3774	-1.811E-06	6.493E-06
34.00	1.3589	0.4040	-1.741E-06	5.979E-06
35.00	1.3047	0.4828	-1.646E-06	5.463E-06
36.00	1.2500	0.4614	-1.526E-06	4.950E-06
37.00	1.1954	0.4921	-1.379E-06	4.440E-06
38.00	1.1413	0.5243	-1.205E-06	3.936E-06
39.00	1.0878	0.5581	-1.002E-06	3.442E-06
40.00	1.0354	0.5934	-7.719E-07	2.958E-06
41.00	0.9842	0.6363	-5.129E-07	2.489E-06
42.00	0.9744	0.6688	-2.258E-07	2.036E-06
43.00	0.8861	0.7089	8.896E-08	1.602E-06
44.00	0.8393	0.7568	4.304E-07	1.188E-06
45.00	0.7942	0.7843	7.975E-07	7.969E-07

TABLE A-8. KEVLAR 49 COMPOSITE PROPERTIES

FIBER PROPERTIES		RESIN PROPERTIES		COMPOSITE PROPERTIES
VF = 0.5500	EF = 1.900E+07	VR = 0.4500	ER = 4.700E+05	RHO = 0.0474
WF = 0.6085	EFT = 1.000E+06	WR = 0.3915	AR = 4.800E-05	FTU = 178750.0
RHOF = 0.0524	GF = 3.000E+05	RHOR = 0.0412	UR = 0.3500	FCU = 38500.0
FTU = 325000.0	AF = -3.440E-06	FSU = 8000.0		FSU = 8000.0
FCU = 70000.0	AFT = 3.000E-05			
UF = 0.2200				

FIBER PROPERTIES		RESIN PROPERTIES		COMPOSITE PROPERTIES
VF = 0.6000	EF = 1.900E+07	VR = 0.4000	ER = 4.700E+05	RHO = 0.0479
WF = 0.6561	EFT = 1.000E+06	WR = 0.3439	AR = 4.000E-05	FTU = 195000.0
RHOF = 0.0524	GF = 3.000E+05	RHOR = 0.0412	UR = 0.3500	FCU = 42000.0
FTU = 325000.0	AF = 3.440E-06	FSU = 8,000.0		FSU = 8000.0
FCU = 70000.0	AFT = 3.000E-05			
UF = 0.2200				

TABLE A-9. KEVLAR 49 MODULI (VF = 0.55)

ALPHA	EX	EY	GXY
0.00	1.066E+07	7.847E+05	2.349E+05
1.00	1.065E+07	7.845E+05	2.380E+05
2.00	1.563E+07	7.840E+05	2.472E+05
3.00	1.859E+07	7.830E+05	2.626E+05
4.00	1.053E+07	7.817E+05	2.840E+05
5.00	1.046E+07	7.800E+05	3.113E+05
6.00	1.037E+07	7.779E+05	3.444E+05
7.00	1.026E+07	7.755E+05	3.832E+05
8.00	1.012E+07	7.727E+05	4.274E+05
9.00	9.968E+06	7.696E+05	4.768E+05
10.00	9.791E+06	7.661E+05	5.312E+05
11.00	9.589E+06	7.623E+05	5.904E+05
12.00	9.364E+06	7.582E+05	6.540E+05
13.00	9.113E+06	7.538E+05	7.217E+05
14.00	8.838E+06	7.491E+05	7.932E+05
15.00	8.538E+06	7.441E+05	8.682E+05
16.00	8.215E+06	7.389E+05	9.483E+05
17.00	7.871E+06	7.335E+05	1.027E+06
18.00	7.509E+06	7.279E+05	1.110E+06
19.00	7.131E+06	7.221E+05	1.195E+06
20.00	6.741E+06	7.162E+05	1.282E+06
21.00	6.343E+06	7.102E+05	1.369E+06
22.00	5.942E+06	7.042E+05	1.457E+06
23.00	5.541E+06	6.983E+05	1.546E+06
24.00	5.145E+06	6.924E+05	1.634E+06
25.00	4.758E+06	6.867E+05	1.721E+06
26.00	4.384E+06	6.812E+05	1.808E+06
27.00	4.025E+06	6.761E+05	1.893E+06
28.00	3.685E+06	6.714E+05	1.976E+06
29.00	3.365E+06	6.674E+05	2.057E+06
30.00	3.066E+06	6.640E+05	2.135E+06
31.00	2.790E+06	6.614E+05	2.210E+06
32.00	2.535E+06	6.599E+05	2.281E+06
33.00	2.303E+06	6.597E+05	2.349E+06
34.00	2.092E+06	6.608E+05	2.413E+06
35.00	1.902E+06	6.537E+05	2.472E+06
36.00	1.732E+06	6.686E+05	2.526E+06
37.00	1.580E+06	6.758E+05	2.576E+06
38.00	1.445E+06	6.857E+05	2.620E+06
39.00	1.326E+06	6.987E+05	2.659E+06
40.00	1.221E+06	7.152E+05	2.692E+06
41.00	1.130E+06	7.358E+05	2.719E+06
42.00	1.050E+06	7.610E+05	2.740E+06
43.00	9.813E+05	7.915E+05	2.756E+06
44.00	9.219E+05	8.279E+05	2.765E+06
45.00	8.711E+05	8.712E+05	2.768E+06

TABLE A-10. KEVLAR 49 MODULI (VF = 0.60)

ALPHA	EX	EY	GXY
0.00	1.159E+07	8.053E+05	2.412E+05
1.00	1.158E+07	8.051E+05	2.445E+05
2.00	1.155E+07	8.045E+05	2.546E+05
3.00	1.151E+07	8.036E+05	2.713E+05
4.00	1.145E+07	8.022E+05	2.947E+05
5.00	1.137E+07	8.005E+05	3.245E+05
6.00	1.127E+07	7.983E+05	3.606E+05
7.00	1.114E+07	7.958E+05	4.029E+05
8.00	1.100E+07	7.930E+05	4.511E+05
9.00	1.083E+07	7.898E+05	5.050E+05
10.00	1.083E+07	7.862E+05	5.644E+05
11.00	1.0412+07	7.823E+05	6.289E+05
12.00	0.106E+07	7.782E+05	6.983E+05
13.00	9.886E+06	7.735E+05	7.721E+05
14.00	9.5812+06	7.687E+05	8.582E+05
15.00	9.249E+06	7.636E+05	9.319E+05
16.00	8.891E+06	7.553E+05	1.017E+06
17.00	8.509E+06	7.527E+05	1.105E+06
18.00	8.107E+06	7.469E+05	1.196E+06
19.00	7.688E+06	7.410E+05	1.288E+06
20.00	7.256E+06	7.349E+05	1.303E+06
21.00	6.816E+06	7.288E+05	1.478E+06
22.00	6.373E+06	7.226E+05	1.575E+06
23.00	5.9322+06	7.165E+05	1.671E+06
24.00	5.497E+06	7.105E+05	1.767E+06
25.00	5.073E+06	7.046E+05	1.863E+06
26.00	4.664E+06	6.990E+05	1.957E+06
27.00	4.273E+06	6.938E+05	2.050E+06
28.00	3.903E+06	6.893E+05	2.140E+06
29.00	3.556E+06	6.848E+05	2.228E+06
30.00	3.233E+06	6.813E+05	2.314E+06
31.00	2.935E+06	6.787E+05	2.395E+06
32.00	2.662E+06	6.772E+05	2.473E+06
33.00	2.413E+06	6.769E+05	2.547E+06
34.00	2.188E+06	6.782E+05	2.617E+06
35.00	1.986E+06	6.812E+05	2.681E+06
36.00	1.805E+06	6.864E+05	2.740E+06
37.00	1.644E+06	6.939E+05	2.794E+06
38.00	1.501E+06	7.042E+05	2.843E+06
39.00	1.375E+06	7.177E+05	2.885E+06
40.00	1.265E+06	7.349E+05	2.921E+06
41.00	1.169E+06	7.563C+05	2.9515+06
42.00	1.085E+06	7.826E+05	2.974E+06
43.00	1.013E+06	8.143E+05	2.991E+06
44.00	9.506E+05	8.524E+05	3.0015+06
45.00	8.975E+05	8.975E+05	3.0045+06

TABLE A-11. KEVLAR 49 STRENGTH ALLOWABLES (VF = 0.55)

ALPHA	FXTU	FYTU	FXCU	FYCU	FXY
0.00	178750.0	0.0	38500.0	2818.7	1413.4
1.00	178134.2	4.8	38474.8	2818.0	1498.5
2.00	176310.4	19.2	38398.7	2816.1	1596.7
3.00	173347.7	43.3	38270.3	2812.7	1709.5
4.00	169353.7	77.0	38087.3	2808.1	1838.6
5.00	164465.9	120.5	37846.7	2802.2	1985.6
6.00	158839.9	173.9	37544.7	2795.0	2152.4
7.00	152638.8	237.2	37176.8	2786.5	2340.7
8.00	146023.3	310.6	36738.3	2776.7	2552.3
9.00	139143.7	394.3	36224.1	2765.8	2789.0
10.00	132134.6	488.5	35629.2	2753.6	3052.2
11.00	125111.4	593.3	34949.3	2740.3	3343.6
12.00	118169.7	708.9	34180.4	2726.0	3664.3
13.00	111385.2	835.7	33320.0	2710.5	4015.3
14.00	104815.7	974.0	32367.0	2694.1	4397.2
15.00	98502.7	1123.9	31322.3	2676.7	4810.2
16.00	92473.9	1286.0	30188.9	2658.5	5253.8
17.00	86746.1	1460.5	28972.5	2639.6	5727.2
18.00	81326.6	1647.8	27681.1	2620.0	6228.8
19.00	76215.9	1848.5	26325.4	2599.9	6756.5
20.00	71409.1	2062.9	24918.4	2579.3	7307.5
21.00	66897.6	2291.6	23474.7	2558.6	7878.3
22.00	62669.8	2535.1	22010.3	2537.8	8465.0
23.00	58712.6	2794.1	20541.8	2517.1	9063.1
24.00	55011.8	3069.2	19085.8	2496.8	9667.8
25.00	51552.6	3361.1	17657.8	2477.2	10273.9
26.00	48320.3	3670.6	16272.2	2458.4	10876.3
27.00	45300.4	3998.4	14941.5	2441.0	11469.6
28.00	42478.7	4345.6	13675.9	2425.2	12048.9
29.00	39841.8	4712.9	12483.3	2411.5	12609.5
30.00	37376.9	5101.4	11369.1	2400.4	13147.0
31.00	35071.8	5512.3	10336.7	2392.5	13657.5
32.00	32915.2	5946.6	9387.3	2388.3	14138.0
33.00	30896.5	6405.8	8520.4	2388.7	14585.9
34.00	29006.0	6891.1	7734.0	2394.4	14999.0
35.00	27234.3	7404.1	7025.0	2406.4	15376.2
36.00	25573.0	7946.3	6389.4	2425.7	15716.5
37.00	24014.4	8519.4	5822.7	2453.6	16019.5
38.00	22551.1	9125.4	5320.1	2491.2	16285.2
39.00	21176.5	9766.3	4876.4	2540.3	16513.9
40.00	19884.3	10444.2	4486.7	2602.4	16706.1
41.00	18669.0	11161.4	4146.0	2679.4	16862.3
42.00	17525.2	11920.6	3849.7	2773.6	16983.0
43.00	16448.1	12724.4	3593.2	2887.2	17068.8
44.00	15433.3	13575.9	3372.4	3022.9	17120.1
45.00	14476.7	14478.2	3183.4	3183.7	17137.2

TABLE A-12. KEVLAR 49 STRENGTH ALLOWABLES (VF = 0.60)

ALPHA	FXTU	FYTU	FXCU	FYCU	FXY
0.00	0.0	0.0	42000.0	2904.8	1460.9
1.00	194288.9	4.9	41972.5	2904.1	1550.0
2.00	192184.6	19.8	41889.3	2902.1	1652.9
3.00	188771.6	44.6	41748.9	2898.6	1771.3
4.00	184181.1	79.3	41548.7	2893.8	1906.9
5.00	178579.5	124.2	41284.9	2887.7	2061.8
6.00	172154.1	179.2	40953.1	2880.3	2237.6
7.00	165099.2	244.4	40548.1	2871.5	2436.5
8.00	157604.1	320.1	40064.4	2861.4	2660.5
9.00	149843.9	406.4	39496.0	2850.1	2911.3
10.00	141973.1	503.4	38837.2	2837.6	3191.0
11.00	134122.3	611.4	36002.6	2823.0	3501.3
12.00	126397.4	730.6	37227.9	2809.0	3843.5
13.00	118880.9	861.4	36270.2	2793.0	4219.0
14.00	111633.6	1003.9	35200.1	2776.0	4628.5
15.00	104898.0	1158.5	34042.9	2758.1	5072.4
16.00	98100.8	1325.6	32778.4	2739.3	5550.5
17.00	91856.4	1505.6	31421.2	2719.7	6062.1
18.00	85969.1	1698.8	29981.1	2699.4	6605.7
19.00	80435.8	1905.8	28470.6	2678.6	7179.0
20.00	75248.0	2127.0	26904.9	2657.4	7779.4
21.00	70393.1	2362.9	25301.0	2636.0	8403.0
22.00	65856.3	2614.3	23677.4	2614.4	9045.8
23.00	61620.7	2881.6	22653.1	2593.0	9702.8
24.00	57669.2	3165.6	20446.6	2572.1	10368.8
25.00	53984.0	3467.0	18875.6	2551.7	11038.0
26.00	50547.7	3786.5	17355.8	2532.3	11704.6
27.00	47343.6	4125.2	15900.6	2514.3	12362.7
28.00	44355.2	4483.8	14521.0	2497.9	13006.6
29.00	41567.4	4863.3	13225.1	2483.7	13630.6
30.00	38965.5	5264.9	12018.3	2472.2	14229.9
31.00	36536.0	5689.7	10903.5	2464.0	14800.1
32.00	34266.2	6138.8	9881.5	2459.7	15337.2
33.00	32144.4	6613.8	8950.9	2460.1	15838.2
34.00	30159.6	7115.9	8109.2	2466.1	16300.7
35.00	28301.7	7646.8	7352.2	2478.5	16723.1
36.00	26561.6	8208.2	6675.4	2498.6	17104.3
37.00	24930.5	8801.8	6073.4	2527.6	17443.7
38.00	23400.7	9429.7	5540.5	2566.8	17741.4
39.00	21964.8	10093.9	5071.2	2617.8	17997.5
40.00	20616.3	10796.8	4659.7	2682.5	18212.7
41.00	19348.9	11540.8	4300.6	2762.9	18387.5
42.00	18156.9	12328.7	3988.8	2861.1	18522.6
43.00	17035.3	13163.4	3719.3	2979.7	18618.7
44.00	15979.3	14047.9	3487.6	3121.6	18676.0
45.00	14984.3	14985.9	3289.6	3289.9	18695.1

TABLE A-13. KEVLAR 49 POISSON'S RATIO AND THERMAL EXPANSION (VF = 0.55)

ALPHA	UXY	UYX	AX	AY
0.00	0.2785	0.205	-2.578E-06	2.844E-05
1.00	0.2824	0.208	-2.587E-06	2.843E-05
2.00	0.2942	0.217	-2.613E-06	2.843E-05
3.00	0.3138	0.232	-2.656E-06	2.841E-05
4.00	0.3410	0.0253	-2.716E-06	2.840E-05
5.00	0.3757	0.0280	-2.794E-06	2.838E-05
6.00	0.4178	0.0313	-2.889E-06	2.835E-05
7.00	0.4668	0.0353	-3.002E-06	2.831E-05
8.00	0.5224	0.0399	-3.132E-06	2.827E-05
9.00	0.5841	0.0451	-3.279E-06	2.822E-05
10.00	0.6513	0.0510	-3.445E-06	2.816E-05
11.00	0.7233	0.0575	-3.627E-06	2.809E-05
12.00	0.7991	0.0647	-3.828E-06	2.802E-05
13.00	0.8777	0.0726	-4.045E-06	2.792E-05
14.00	0.9580	0.0812	-4.280E-06	2.782E-05
15.00	1.0387	0.0905	-4.532E-06	2.770E-05
16.00	1.1184	0.1006	-4.800E-06	2.756E-05
17.00	1.1958	0.1114	-5.085E-06	2.739E-05
18.00	1.2694	0.1230	-5.384E-06	2.721E-05
19.00	1.3379	0.1355	-5.698E-06	2.700E-5
20.00	1.4001	0.1487	-6.024E-06	2.676E-05
21.00	1.4547	0.1629	-6.361E-06	2.649E-05
22.00	1.5010	0.1779	-6.707E-06	2.618E-05
23.00	1.5383	0.1939	-7.059E-06	2.582E-05
24.00	1.5662	0.2108	-7.413E-06	2.542E-05
25.00	1.5845	0.2287	-7.767E-06	2.497E-05
26.00	1.5934	0.2476	-8.114E-06	2.446E-05
27.00	1.5932	0.2676	-8.449E-06	2.388E-05
28.00	1.5845	0.2887	-8.764E-06	2.323E-05
29.00	1.5679	0.3109	-9.052E-06	2.251E-05
30.00	1.5442	0.3344	-9.304E-06	2.170E-05
31.00	1.5142	0.3590	-9.507E-06	2.079E-05
32.00	1.4789	0.3850	-9.652E-06	1.979E-05
33.00	1.4392	0.4122	-9.723E-06	1.869E-05
34.00	1.3957	0.4408	-9.708E-06	1.749E-05
35.00	1.3495	0.4708	-9.591E-06	1.618E-05
36.00	1.3011	0.5023	-9.357E-06	1.477E-05
37.00	1.2513	0.5352	-8.992E-06	1.325E-5
38.00	1.2006	0.5697	-8.483E-06	1.165E-05
39.00	1.1495	0.6056	-7.820E-06	9.969E-06
40.00	1.0984	0.6432	-6.995E-06	8.228E-06
41.00	1.0477	0.6823	-6.005E-06	6.448E-06
42.00	0.9978	0.7230	-4.852E-06	4.654E-06
43.00	0.9487	0.7652	-3.546E-06	2.874E-06
44.00	0.9008	0.8090	-2.098E-06	1.136E-06
45.00	0.8542	0.8543	-5.289E-07	-5.316E-07

TABLE A-14. KEVLAR 49 POISSON'S RATIO AND THERMAL EXPANSION (VF = 0.60)

ALPHA	UXY	UYX	AX	AY
0.00	0.2720	0.0189	-2.735E-06	2.821E-05
1.00	0.2762	0.0192	-2.744E-06	2.820E-05
2.00	0.2887	0.201	-2.770E-06	2.620E-05
3.00	0.3095	0.0216	-2.813E-06	2.819E-05
4.00	0.3384	0.0237	-2.874E-06	2.817E-05
5.00	0.3734	0.0264	-2.952E-06	2.815E-05
6.00	0.4201	0.0298	-3.047E-06	2.812E-05
7.00	0.4722	0.0337	-3.160E-06	2.808E-05
8.00	0.5313	0.0383	-3.291E-06	2.804E-05
9.00	0.5969	0.0435	-3.439E-06	2.799E-05
10.00	0.6683	0.0494	-3.605E-06	2.794E-05
11.00	0.7447	0.0559	-3.768E-06	2.787E-05
12.00	0.8251	0.0632	-3.989E-06	2.779E-05
13.00	0.9084	0.0711	-4.208E-06	2.770E-05
14.00	0.9933	0.0797	-4.444E-06	2.760E-05
15.00	1.0784	0.0890	-4.697E-06	2.748E-05
16.00	1.1623	0.991	-4.967E-06	2.734E-05
17.00	1.2434	0.1100	-5.253E-06	2.718E-05
18.00	1.3203	0.1216	-5.554E-06	2.699E-05
19.00	1.3914	0.1341	-5.870E-06	2.679E-05
20.00	1.4554	0.1474	-6.198E-06	2.655E-05
21.00	1.5113	0.1616	-6.538E-06	2.[illegible]3E-05
22.00	1.5580	0.1767	-6.887E-06	2.597E-05
23.00	1.5951	0.1927	-7.242E-06	2.562E-05
24.00	1.6220	0.2097	-7.601E-06	2.522E-05
25.00	1.6[illegible]87	0.2276	-7.958E-06	2.477E-05
26.00	1.6455	0.2466	-8.310E-06	2.426E-05
27.00	1.6428	0.2667	-8.650E-06	2.368E-05
28.00	1.6312	0.2880	-8.971E-06	2.303E-05
29.00	1.6115	0.3103	-9.265E-06	2.231E-05
30.00	1.5846	0.3339	-9.523E-06	2.150E-05
31.00	1.5514	0.3587	-9.733E-06	2.060E-05
32.00	1.5129	0.3849	-9.884E-06	1.960E-05
33.00	1.4700	0.4123	-9.963E-06	1.850E-05
34.00	1.4235	0.4412	-9.954E-06	1.729E-05
35.00	1.3744	0.4715	-9.844E-06	1.598E-05
36.00	1.3234	0.5032	-9.616E-06	1.456E-05
37.00	1.2711	0.5365	-9.257E-06	1.305E-05
38.00	1.2181	0.5714	-8.753E-06	1.144E-05
39.00	1.1649	0.6078	-8.093E-06	9.751E-06
40.00	1.1120	0.6459	-7.271E-06	8.003E-06
41.00	1.0596	0.6856	-6.281E-06	6.215E-06
42.00	1.0081	0.7270	-5.128E-06	4.413E-06
43.00	0.9577	0.7700	-3.819E-06	2.625E-06
44.00	0.9085	0.8146	-2.367E-06	3.792E-07
45.00	0.8609	0.8609	-7.920E-07	-7.947E-07

APPENDIX B

ANGLE BRACKET STUDY

Tension fittings, frequently referred to as "bathtub" fittings (Figure B-1), provide an effective method of transferring axial load across removable helicopter joints. This type of fitting is commonly fabricated from metals whose strength and stiffness are essentially the same in all directions (i.e., they are isotropic and homogeneous).

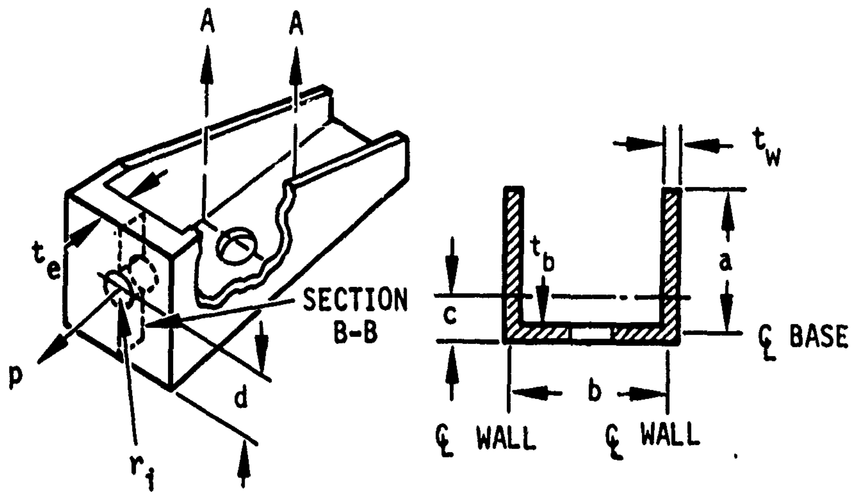


Figure B-1. "Bathtub" Tension Fitting

The design and fabrication of similar fittings from reinforced composites present several problems that do not arise in the design of metal fittings:

- The strength and stiffness of composite materials depend on fiber orientation.

- The bearing and shear strengths of composites are low in comparison with their unidirectional tensile strength and the tensile strength of metals.

- The three-dimensional state of stress that exists in composite fittings complicates the analysis of these structures.

- The failure modes of composites are different from those of metals.

A major problem in designing attachment fittings using reinforced composites is "turning the corner." A simple example is the bolted angle bracket shown in Figure B-2. In bolted angle brackets, a tension load applied to one leg of the angle is reacted by a shear load in the other leg. As a result of the inherent eccentricity, a bending moment is present in both legs and, in particular, in the radius of the angle. In composites, the transfer of the load from tension in one leg to shear in the other and the transfer of the bending moment around the corner limit the strength of the fitting because composites possess nonuniform properties. The situation is complicated by several discontinuities:

- The tension bolt-washer interface

- The turn-the-corner problem

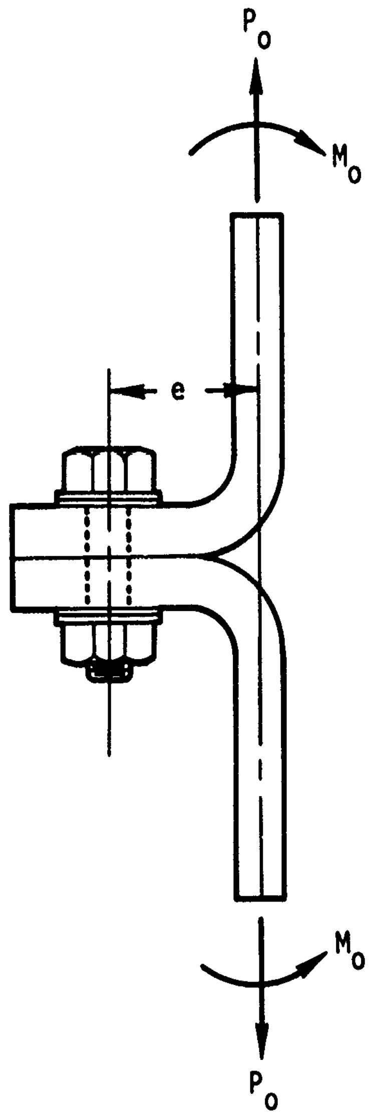
- The load distribution around the hole

- The material behavior

This problem had to be solved in order to design effective composite tension fittings. An analytical solution was required, along with experimental data to verify the accuracy of the analysis.

METHODOLOGY

The nature of the stress field in the corner of an angle bracket was investigated using several theoretical methods including classical two-dimensional thin laminate theory, thick laminated plate theory, and cylindrical shell theory. Results obtained using the two-dimensional classical theory were comparable with parametric study results obtained using finite element models C-1 and C-2.



P_o = APPLIED TENSION LOAD

M_o = MOMENT DUE TO ECCENTRICITY e

Figure B-2. Turning the Corner

When a pure axial tension load is applied to an angle bracket (Figure B-3), the internal axial, shear, and moment loads vary as a function of the bend angle θ. These loads are simply:

$$N_\theta = N_0 \cos\theta$$

$$S_\theta = N_0 \sin\theta$$

$$M_\theta = N_0 \bar{R} (1 - \cos\theta)$$

where the distance to the center of the laminate is $\bar{R} = R_0 + t/2$. At high values of θ, the shear and moment loads will create critical interlaminar shear and transverse tensile stresses. These effects will be discussed with the NASTRAN results.

The reduced stiffnesses of an orthotropic lamina in a flat composite plate are:

$$Q_{11} = \frac{E_1}{1 - \nu_{12}\nu_{21}}$$

$$Q_{12} = \frac{\nu_{12} E_2}{1 - \nu_{12}\nu_{21}} = \frac{\nu_{21} E_1}{1 - \nu_{12}\nu_{21}}$$

$$Q_{22} = \frac{E_2}{1 - \nu_{12}\nu_{21}}$$

$$Q_{66} = G_{12}$$

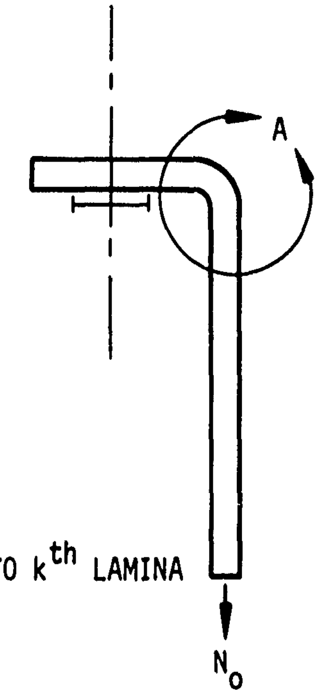
where

E_1, E_2 = Young's moduli in one and two directions, respectively

ν_{ij} = Poisson's ratio for transverse strain in the j-direction when stressed in the i-direction

G_{12} = shear modulus in the 1-2 plane

N_θ = NORMAL STRESS
S_θ = SHEAR STRESS
M_θ = MOMENT
R_o = INSIDE RADIUS
$\bar{R}$ = AVERAGE RADIUS
N_o = APPLIED LOAD
t_k = THICKNESS OF k^{th} LAMINA
h_k = DISTANCE FROM AVERAGE RADIUS TO k^{th} LAMINA



DETAIL A

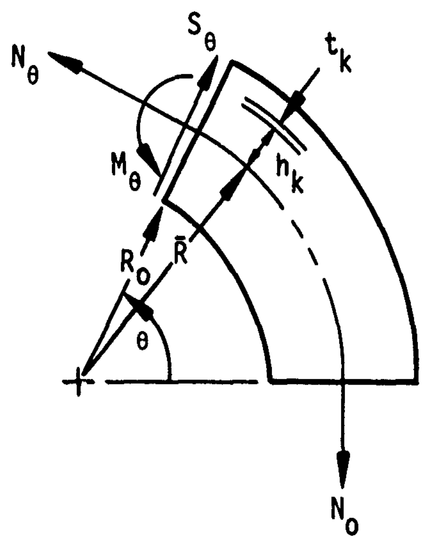


Figure B-3. Internal Loads in the Corner Region

Laminated bending stiffnesses are defined as

$$D_{ij} = \frac{1}{3} \sum_{k=1}^{N} \left(\bar{Q}_{ij}\right)_k \left(h_k^3 - h_{k-1}^3\right)$$

where Q_{ij} are the reduced stiffnesses when transformed to a rotated x-y axis and h_k is defined in Figure B-4.

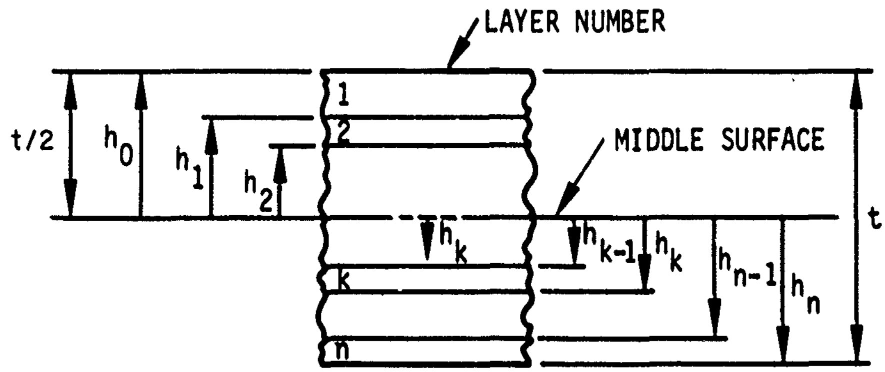


Figure B-4. Laminate Geometry

The normalized tangential stress in the corner of an angle bracket is

$$\frac{\sigma_\theta^k}{\sigma_0} = \left\{ \frac{t\left(R_0 + t/2\right)\left[1 - \cos\theta\right]\left(h_k + t_k/2\right)}{D_{\theta\theta}} + \frac{\cos\theta}{Q_{\theta\theta}} \right\} Q_{\theta\theta}^k$$

where $D_{\theta\theta}$ and $Q_{\theta\theta}$ are equal to D_{11} and Q_{11}, respectively, and $\sigma_0 = N_0/t$. At θ equal to 0 degrees, there is no bending stress component, as expected.

Similarly, the normalized interlaminar shear stress in the corner region was evaluated as

$$\frac{\tau_{r\theta}^k}{\sigma_0} = \frac{t \sin\theta}{2G_{r\theta}} \left[\left(t/2\right)^2 - \left(h_k + t_k/2\right)^2\right] G_{r\theta}^k$$

where $G_{r\theta}$ is the laminate shear modulus using the radial coordinate system. Given a particular lamina, the value of $\tau^k_{r\theta}/\sigma_0$ varies as a function of sin θ.

Despite the relative simplicity of these equations, the results show excellent agreement with results obtained using the NASTRAN C-1 and C-2 preprocessor models developed for this contracted effort.

FINITE ELEMENT MODEL

Modeling Considerations

The finite element model of the angle bracket to be investigated was designed in accordance with the following considerations:

- Since the geometry of the bracket fitting and the applied loads are both symmetrical, it is necessary to analyze only half of the bracket, using appropriate boundary constraints.

- To avoid using a dense mesh and yet obtain reliable results in critical parts of the bracket (parts with high stress/strain gradients), higher-order isoparametric solid elements (HEXA, PENTA) are employed.

- For modeling purposes, the bracket is subdivided into four parts (Figure B-5) such that each part can be independently provided with a mesh size appropriate to its stress/strain gradients.

- The mesh size for each bracket part is chosen so as to lend itself to automatic resolution into discrete strips and automatic numbering by appropriate preprocessors.

- To obtain the magnitude of the interlaminar stresses, several layers of elements are provided across the thickness of the bracket to represent the actual laminated construction.

- The bracket is subdivided along its width into a reasonable number of uniform strips such that it is convenient to identify critical zones and, when desirable, possible to extract and subject individual strips to detailed interlaminar analysis (Figure B-6).

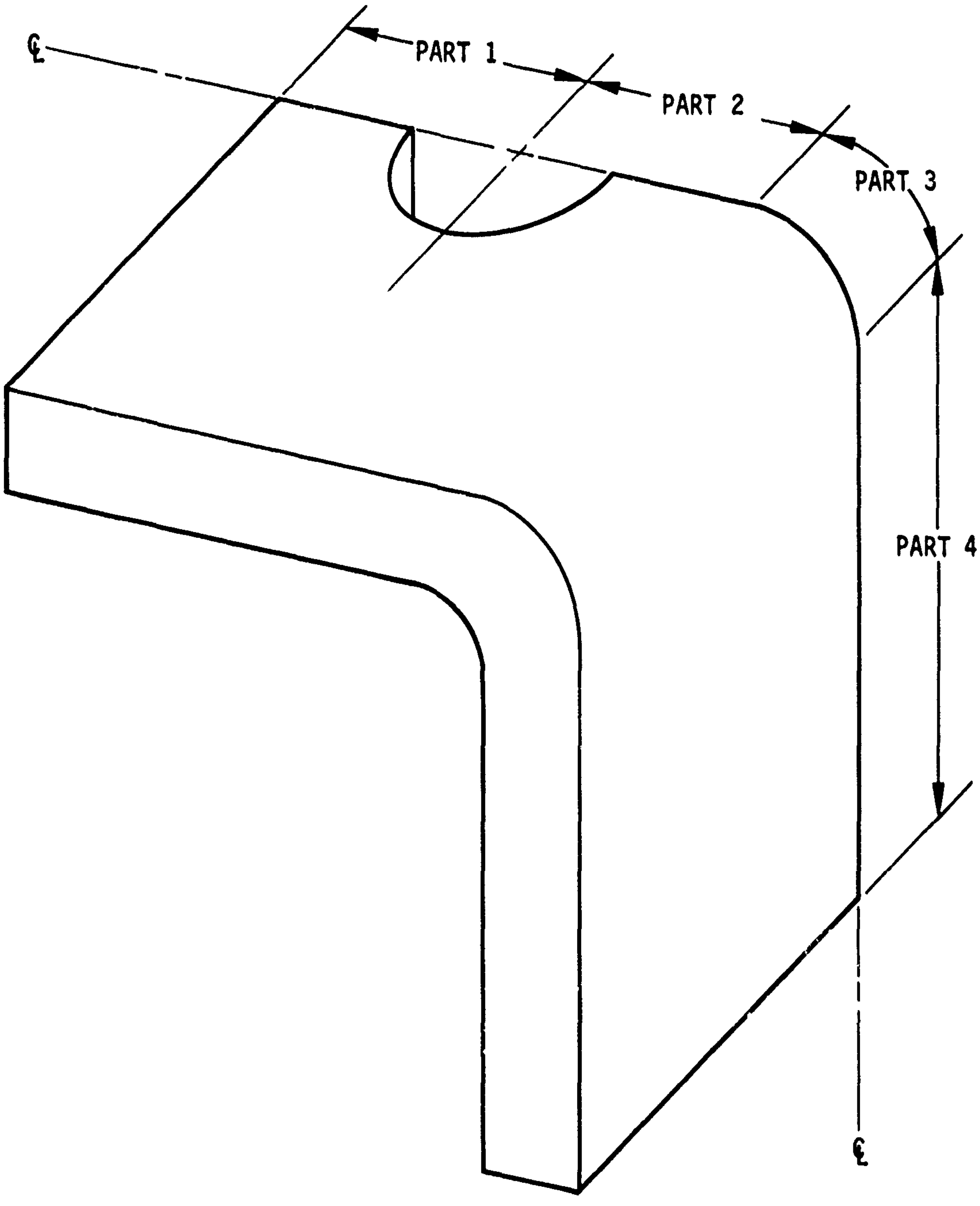


Figure B-5. Angle Bracket Subdivision

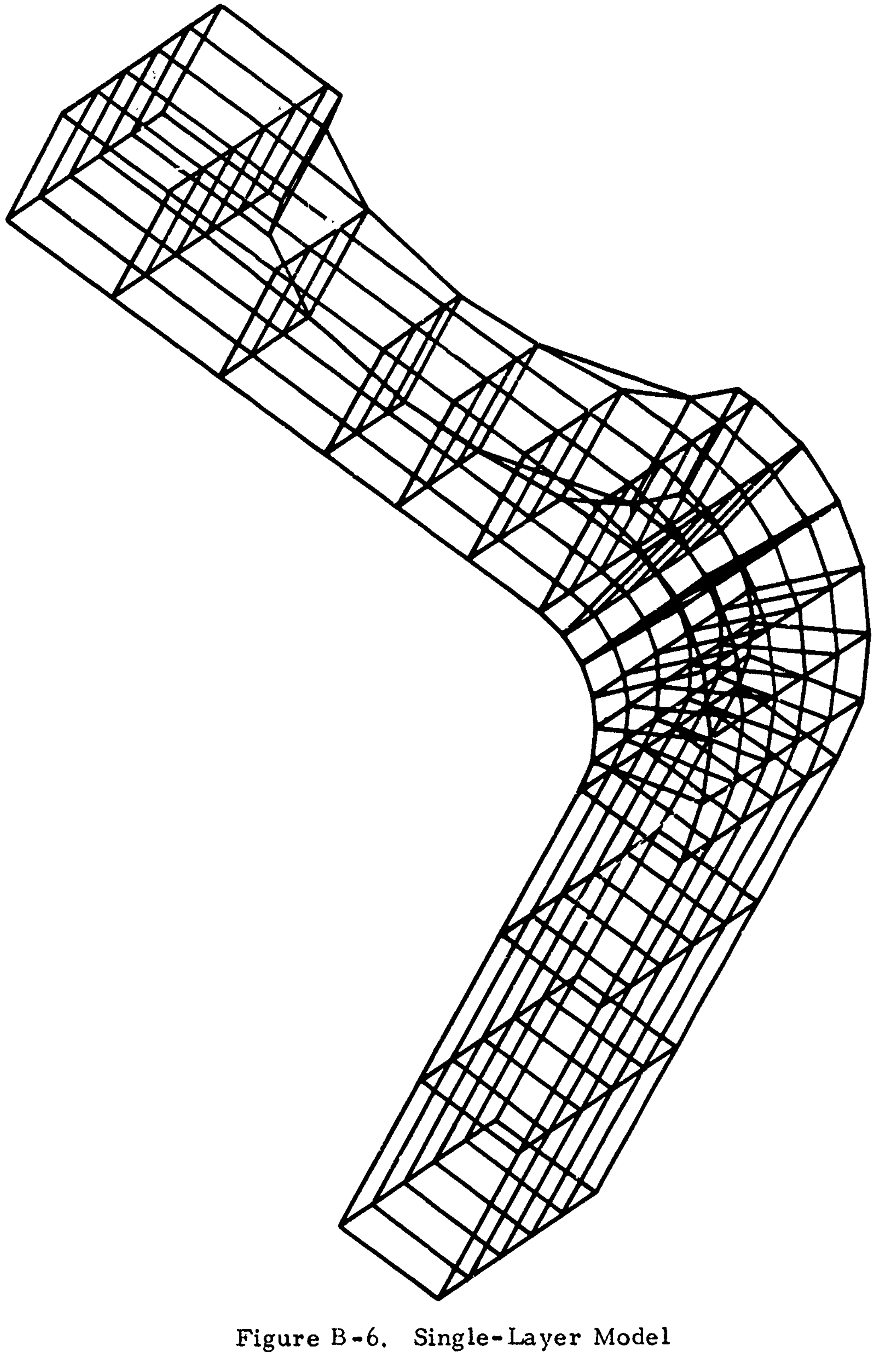


Figure B-6. Single-Layer Model

Preprocessors

To minimize computer cost, it was decided to develop two FORTRAN preprocessor programs (C-1 and C-2) capable of automatically forming the finite element meshes for a given bracket and generating the associated Bulk Data decks (Figure B-7).

In the first stage of the analysis, the C-1 preprocessor idealizes the whole (half-symmetrical) bracket into either a single- or a multilayer model with a given number of strips across the width of the bracket. A full model NASTRAN can then be conducted.

The C-2 preprocessor simply extracts that part of the C-1 model output that is associated with a specific critical strip so that a single strip NASTRAN can be conducted.

Parametric studies can be run using either the output of the full model NASTRAN analysis after a C-1 run or the output of the single strip NASTRAN after a C-2 run.

Note that a separate C-1 run is made for the specific multilayer construction of the angle in question before the second stage of the analysis (the C-2 run) is conducted.

Step-by-Step NASTRAN Procedure

The steps involved in determining the magnitude of the interlaminar stresses in any given composite bracket by this two-stage procedure are as follows:

- List the dimensions of the bracket, the dimensions of the elements for all four regions, and the equivalent solid laminate material properties.
- Execute the C-1 preprocessor model, entering the above information as input, to obtain the bulk data for a single-layer, multistrip model run.
- Supplement the C-1 output with appropriate Executive Control and Case Control decks and the required additional Bulk Data cards to make a data check and plot run with identification numbers for grid points and elements.
- Modify the above deck to conduct the full model NASTRAN for the solid laminate bracket.

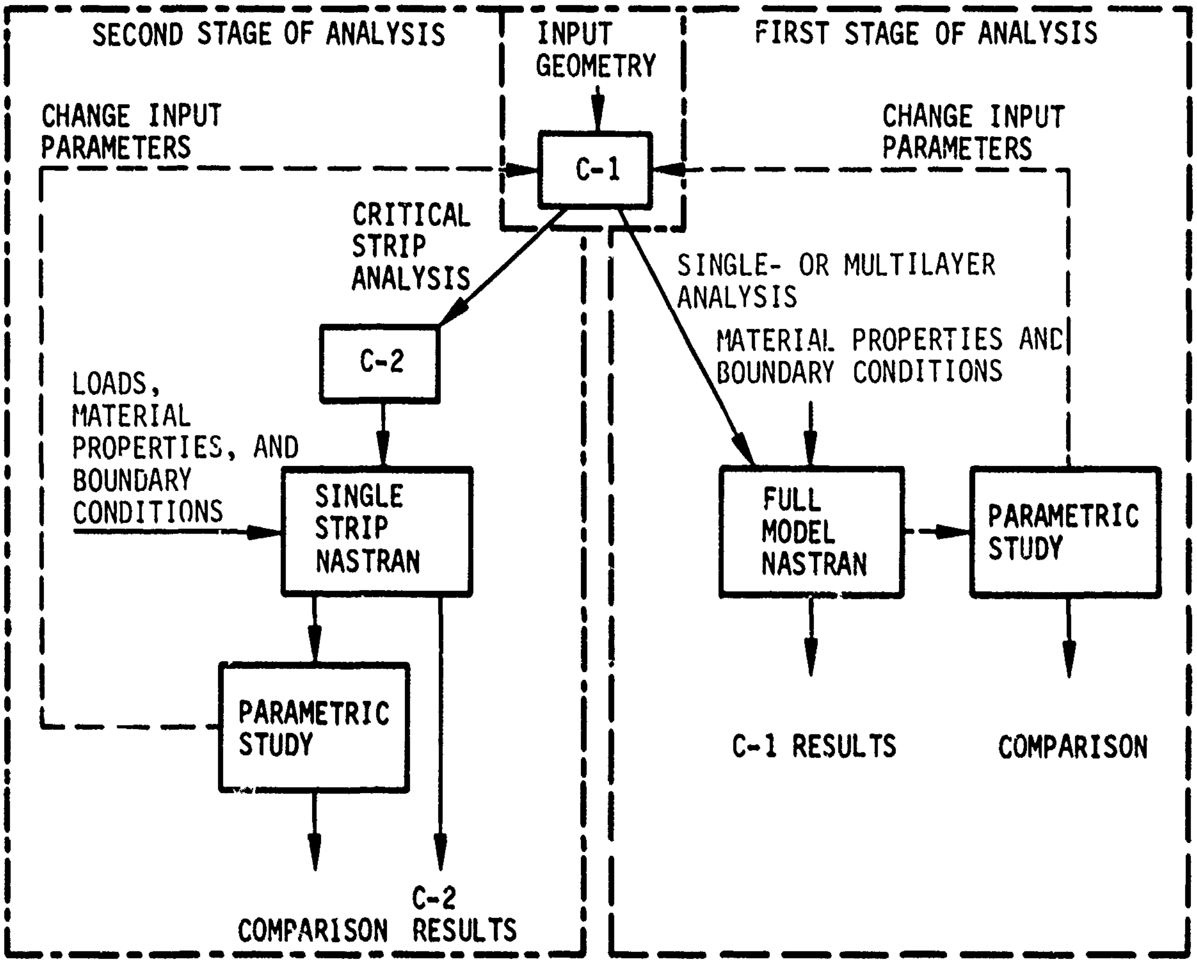


Figure B-7. Two-Stage Computer Analysis Flowchart

- Examine the results to identify regions of high stress/strain gradients and select the critical strip to investigate interlaminar behavior.

- Rerun the C-1 preprocessor model for a multilayered mesh that represents the actual laminated construction.

- Execute the C-2 preprocessor model to extract the multilayer bulk data for the critical strip, using the results of the second C-1 model run as input.

- Supplement the C-2 output with the necessary Executive Control, Case Control, and Bulk Data cards to make a data check and plot run with elements and grid points labeled.

- Modify the above deck to perform the final single strip NASTRAN to obtain interlaminar stress results within the critical strip.

FULL MODEL C-1 PREPROCESSOR

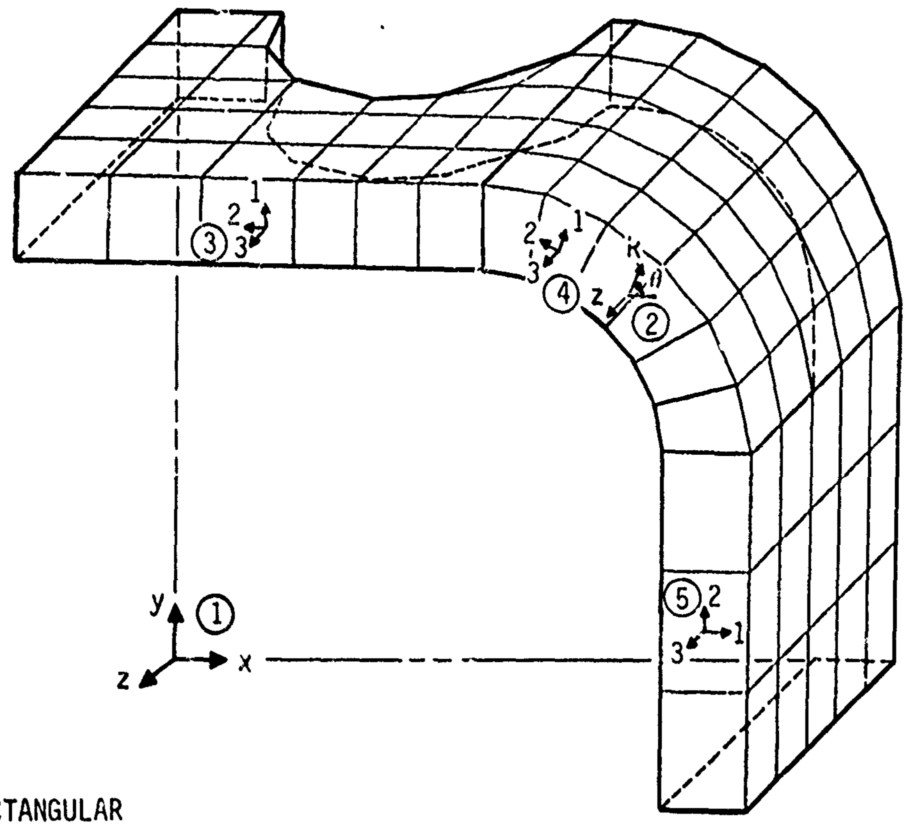
The C-1 preprocessor first analyzes the portion of the bracket to the left of the centerline of the washer and then, in a similar manner, the portion to the right of the centerline up to the tangent line where the bend starts. Particular care is taken to ensure that the grid points accurately trace the circular washer circumference and that the appropriate wedge-shaped elements (PENTAs) are provided in combination with the solid (HEXA) elements near the circumference. The cylindrical part of the bracket is then modeled using diverging HEXA elements and, finally, the loaded leg (Part 4) is idealized using the rectangular HEXA elements.

The program is capable of modeling up to 25 layers across the thickness of the bracket.

Coordinate Systems

In order to locate the grid points, to obtain a printout of node displacements along desired directions, and to account for specific material orientations, five coordinate systems are employed (Figure B-8). These coordinate systems are defined by NASTRAN CORD2 Bulk Data cards, and their ID numbers are appropriately referenced when the related GRID and PSOLID cards are input. These five coordinate systems are:

- The basic rectangular coordinate system, with its origin placed directly below the left rear corner of the angle such that the xyz



BASIC RECTANGULAR
COORDINATE SYSTEM (1)

LOCAL CYLINDRICAL COORDINATE
SYSTEM (2) USED TO LOCATE GRID POINTS
ON CYLINDRICAL PART OF BRACKET

THREE LOCAL COORDINATE SYSTEMS USED TO DEFINE
ANISOTROPIC MATERIAL PROPERTIES OF SOLID ELEMENTS
THAT CONSTITUTE PAPTS 1 AND 2 (3) , PART 3 (4) ,
AND PART 4 (5)

Figure B-8. C-1 Coordinate Systems

coordinates of all grid points have positive values. The grid points of all the flat regions (Parts 1, 2, and 4) are located with reference to this system, which is directed by an appropriate entry in Field 3 of the GRID card. The displacements, degrees of freedom, and constraints at all grid points are also defined with reference to this basic coordinate system by making a corresponding entry in Field 7 of the appropriate GRID cards.

- A local cylindrical coordinate system (defined with reference to the basic system described above) used for locating the grid points on the cylindrical part of the bracket. Field 3 of the corresponding GRID cards defines this system.

- Three local coordinate systems (also established with reference to the basic system) used to define the anisotropic material properties of the solid elements constituting Parts 1 and 2, Part 3, and Part 4, respectively, of the bracket. Systems 3 and 5, which are rectangular, correspond to the flat parts, and System 4, which is cylindrical, pertains to the curved part.

  These systems are referenced on the appropriate PSOLID card, which in turn references the corresponding MAT9 card. The orientation of these systems was selected such that Direction 1 is consistently normal to and radiating out of all elements of the bracket. All laminae composing the bracket are thus parallel to Plane 2-3 of the related material coordinate system at all locations. This orientation, which is dictated by the geometry of the cylindrical part, allows the material properties of any continuous lamina to be defined in a consistent manner. 6 B

  The NASTRAN program prints out the element stresses in directions parallel to the corresponding material coordinate systems.

Grid Point and Element Numbering Schemes

The C-1 preprocessor model lays out the mesh and assigns identification numbers for the grid points and elements at the top and bottom of each layer, as illustrated (for a single-layer model) in Figure B-9. First, the grid points on the bottom surface of Part 1 are numbered, starting from the washer centerline and proceeding in a sweeping fashion in the -x direction toward the free edge. The numbers are assigned consecutively, starting with 1. The program then moves to the top surface (in the +y direction), increments the ID numbers by 10,000, and assigns grid point IDs in the same manner as for the bottom surface.

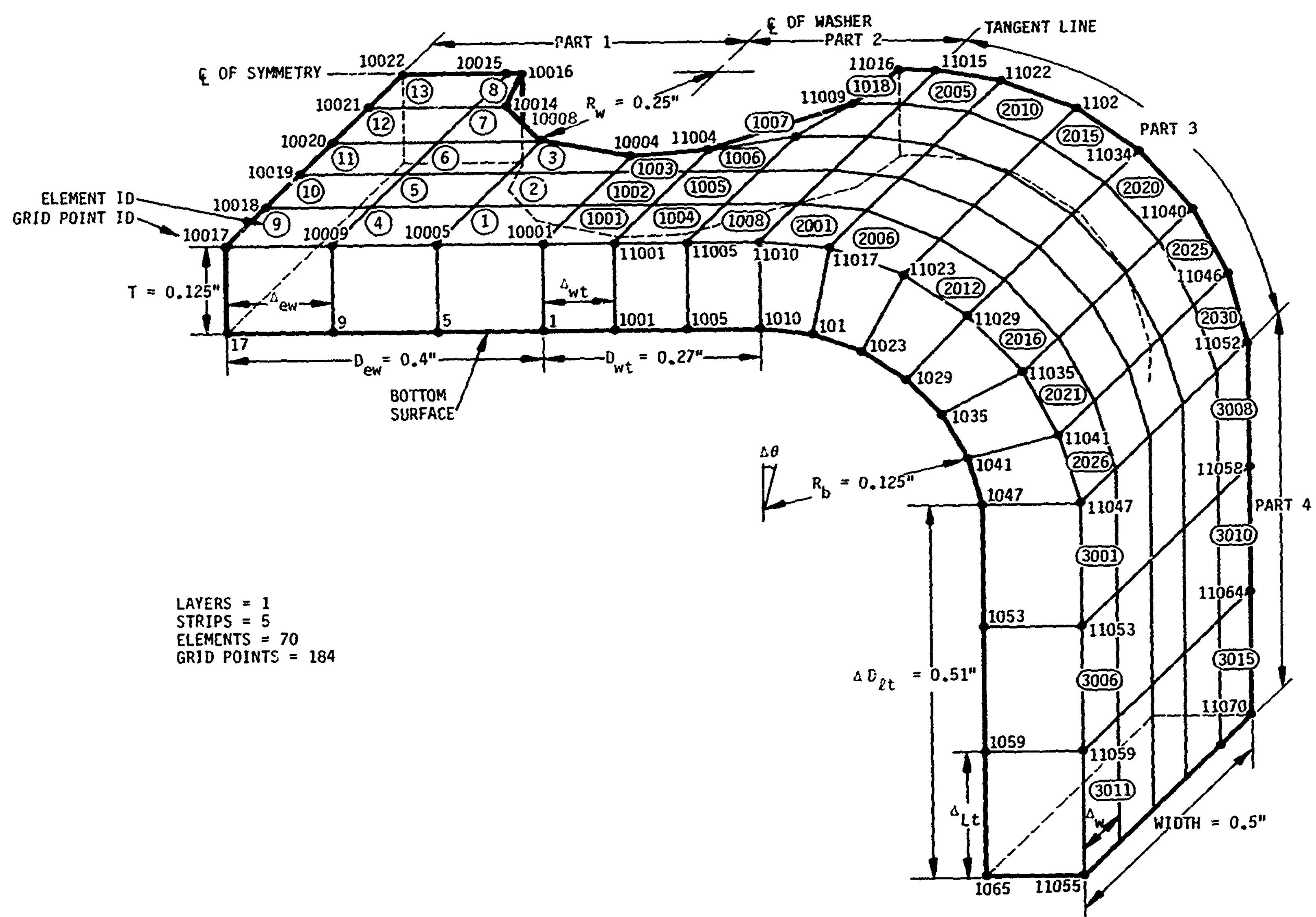


Figure B-9. Grid Point and Element ID Numbers

For models with more than one layer, the program moves up one layer at a time until it reaches the top surface. The elements for Part 1 are numbered following the same general directions as for the grid point numbering.

After the grid points and elements of Part 1 have been numbered, the program provides grid point IDs for the bottom surface of Part 2, starting with number 1001 and moving from the washer centerline to the tangent line. The numbers of the nodes one layer higher are incremented by 10, 000, and the element IDs start with 11, 001.

The grid points for Parts 3 and 4 are given numbers consecutive with those assigned to Part 2. The element numbers for Part 3 start with 2001 and those for Part 4 start with 3001.

The ID numbers given to grid points near the washer should be carefully noted because that area is numbered according to a modified scheme to account for the circular boundary and the wedge-shaped elements required to model it.

C-1 Input Data

The user essentially specifies the basic dimensions of the bracket and the desired fineness of the mesh by giving the number of divisions along the three axes for each of the four parts of the bracket. The required input parameters are defined as:

Width (W) = Width of the modeled half-symmetrical bracket, which remains uniform over all four parts.

Δ_w = Typical element dimension in the width direction, also uniform over all four parts.

Thickness (T_i) = Thickness of the i^{th} lamina, entered as T(1), (T2),...., T(n), starting from the bottom.

Layers = Number of laminae making up the total thickness. Up to 25 layers may be specified (Default = 1).

D_{ew} = Distance from the free transverse edge to the center of the washer defining the limits of Part 1.

Δ_{ew} = Typical element dimension in the D_{ew} direction. Along with Δ_w, this parameter establishes the mesh density in Part 1.

R_w = Radius of washer or circular opening in the model.

D_{wt} = Distance from the center of the washer to the tangent line defining the limits of Part 2.

Δ_{wt} = Typical element dimension in the D_{wt} direction. Along with Δ_w, this parameter establishes the mesh density in Part 2.

R_b = Inside radius of the cylindrical part (bend radius).

Δ_θ = Typical angle (in degrees) subtended by the radial faces of the converging elements of the cylindrical part. Along with Δ_w, this parameter establishes the mesh density in Part 3.

D_{lt} = Distance from the transverse loaded edge to the closest tangent line. This parameter defines the limits of Part 4.

Δ_{lt} = Typical element dimension in the D_{lt} direction. Along with Δ_w, this parameter establishes the mesh density in Part 4.

Tolerance = This parameter controls the element dimensions while fitting the elements in around the circumference of the washer. It defines the minimum length to which the side of an element may be reduced, or the maximum length to which an element may be increased to meet the circular boundary.

Actual data input to the C-1 preprocessor consists of the names of the parameters (Table B-1) and their respective values, entered in free format and in free order. Lines 898 through 901 of the program listing, presented as Appendix C, constitute an example of user data input (this example corresponds to the bracket illustrated in Figure B-9). An echo of the input parameters is printed along with the run cutput.

A comprehensive flow chart showing the sequence of program operations is given in Appendix D.

TABLE B-1. INPUT PARAMETER NAMES

Input Parameters	Parameter Names
Width	WIDTH
Δ_w	DELTAX
Thickness T(i)	T(i)
Layers	LAYERS
D_{ew}	HT2
Δ_{ew}	DELTY2
R_w	RADIUS
D_{wt}	LEGX1
Δ_{wt}	DELTAY
R_b	BEND
Δ_θ	DELTAT
D_{lt}	LEGY
Δ_{lt}	DELTAZ
Tolerance	TOLER

Job Control Statements

The first part of the C-1 model JCL (job control list) is a command to execute FORTRAN programs, and the second part specifies the disposition of the output (save or dispose). The JCL for the source program listing shown in Appendix C is valid for the IBM 360/370 computer. Lines 1 and 2 show the user ID and the Execute FORTRAN command. Lines 895 through 897 specify that Tape Unit 7 be saved and catalogued on on-line disk pack WYLBUR. Tape Unit 7 contains the NASTRAN Bulk Data card images, which are to be used for the subsequent stress analysis run.

Typical C-1 Output

The program produces three types of output: an echo of the input parameters, error messages, and the Bulk Data cards CHEXA, CPENTA, GRID, and CORD2C, printed in 8-column NASTRAN format. The first two types of output are written on Tape Unit 6 and are printed along with the preprocessor run, and the bulk data is written on Tape Unit 7 and saved on an on-line disk pack to be supplemented with additional data for the subsequent NASTRAN run. Appendix E shows the C-1 model preprocessor program output, and Appendix F presents the bulk data generated by the program.

FULL MODEL NASTRAN

To conduct a full model NASTRAN, the Bulk Data cards generated by the C-1 preprocessor model must be supplemented by appropriate Executive Control, Case Control, and Bulk Data cards defining the boundary conditions, material properties, and loading.

Boundary Conditions

Figure B-10 shows the constraints imposed on the bracket:

- The top edge of the free transverse side is restrained from motion in the vertical direction (U2 = 0).
- The washer boundary (circular opening) is assumed to be rigidly constrained (U1 = U2 = U3 = 0) along both the top and the bottom edges.
- Since only half the bracket is modeled (because of structural and loading symmetry), appropriate boundary conditions (U3 = 0) are imposed on all grid points along the face of symmetry.

All these constraints are effected by including additional SPC1 cards in the Bulk Data deck and the corresponding SPC card in the Case Control deck. Since HEXA and PENTA elements relate only to the translational degrees of freedom (1, 2, and 3), the GRDSET card is used to constrain all the rotational degrees of freedom (4, 5, and 6) and thus prevent the singularity problem.

CONSTRAINED AT CENTERLINE FOR SYMMETRY

WASHER BOUNDARY FIXED

EDGE CONSTRAINED NORMALLY

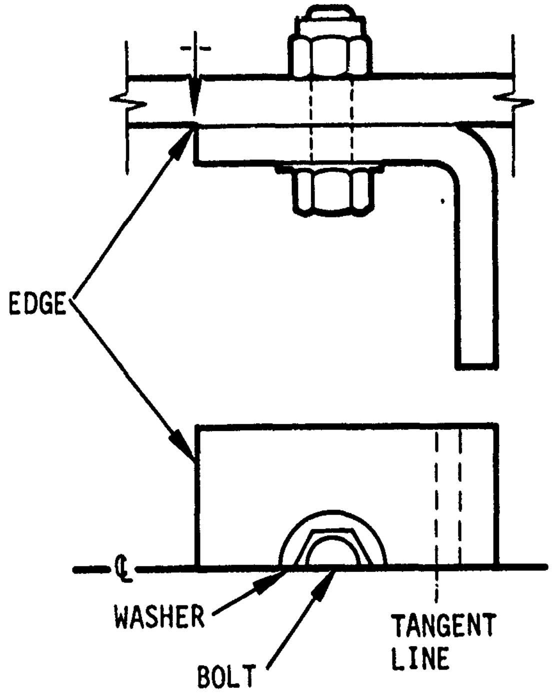


Figure B-10. C-1 Boundary Conditions

Material Properties

The bracket construction is defined by including PSOLID and MAT9 cards in the Bulk Data deck. The appropriate material coordinate system is input on the PSOLID card, and a symmetric 6 by 6 material property matrix G_{ij} is input on the MAT9 card to define the anisotropic properties of the solid, isoparametric elements. For the laminated bracket, the G_{ij} matrix is defined as

$$\left[G_{ij}\right] = \begin{bmatrix} \frac{(1-\nu_{23}\nu_{32})E_{11}}{\nu} & \frac{(\nu_{21}+\nu_{23}\nu_{31})E_{11}}{\nu} & \frac{(\nu_{31}+\nu_{12}\nu_{32})E_{11}}{\nu} & 0 & 0 & 0 \\ & \frac{(1-\nu_{31}\nu_{13})E_{22}}{\nu} & \frac{(\nu_{32}+\nu_{12}\nu_{31})E_{22}}{\nu} & 0 & 0 & 0 \\ & & \frac{(1-\nu_{12}\nu_{21})E_{33}}{\nu} & 0 & 0 & 0 \\ & & & G_{12} & 0 & 0 \\ & \text{SYMMETRIC} & & & G_{23} & 0 \\ & & & & & G_{31} \end{bmatrix}$$

where

$$\nu = 1 - \nu_{12}\,\nu_{21} - \nu_{23}\,\nu_{32} - \nu_{31}\,\nu_{13} - 2\nu_{12}\,\nu_{23}\nu_{31}$$

for the k^{th} lamina

$$\left[\bar{G}^k\right] = \left[T^k\right]^{-1}\left[G^k\right]\left[T^k\right]$$

where

$$
\left[T^k\right] = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & m^2 & n^2 & 0 & 2mn & 0 \\ 0 & n^2 & m^2 & 0 & -2mn & 0 \\ 0 & 0 & 0 & m & 0 & -n \\ 0 & -mn & mn & 0 & (m^2 - n^2) & 0 \\ 0 & 0 & 0 & n & 0 & m \end{bmatrix}
$$

and

$$m = \cos\theta$$

$$n = \sin\theta$$

where the transformation matrix T^k for the k^{th} lamina define a rotation about the x axis as illustrated in Figure B-11.

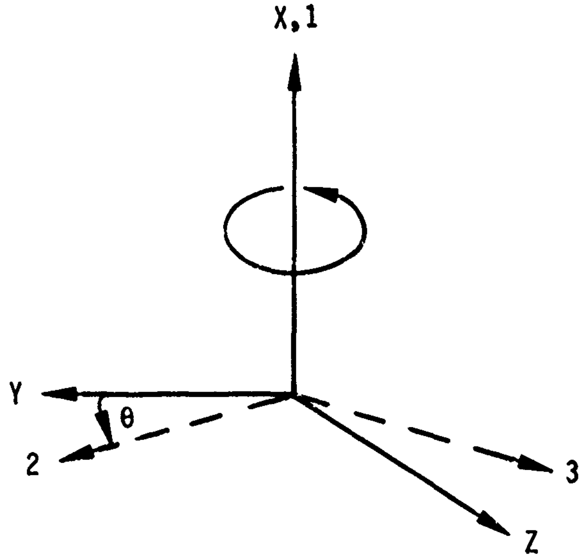


Figure B-11. Rotation of Axis

Applied Loads

Two load conditions were imposed on the C-1 bracket model:

- A uniformly distributed tension load across the loaded transverse edge (Figure B-12a)
- A uniformly distributed clockwise couple across the edge to compensate for eccentric tensile loads (Figure B-12b)

Figure B-12. Load Conditions

These loads are applied by including FORCE cards in the Bulk Data deck and the corresponding LOAD cards in the Case Control deck.

Bandwidth (Wavefront) Optimization

It is advisable, especially for large models, to employ a bandwidth or wavefront minimization subroutine to make optimal use of computer resources. With the MSC NASTRAN program, this is accomplished by using a NASTRAN preprocessor card (parameter PREOPT = 1).

C-1 Data Check and Plot Run

Before making a solution run, it is desirable to examine the preprocessor-produced finite element model by making a data check and plot run using several carefully selected points. Appendix G shows the NASTRAN data deck setup for making a data check and plot run and the undeformed structure plots produced.

Care should be taken to save the plot files by inputting the proper job control statements.

NASTRAN C-1 Solution Run

To make a NASTRAN solution run, the following cards must be added to the Bulk Data deck generated by the C-1 preprocessor:

- NASTRAN wavefront optimization card (PREOPT = 1)
- Executive Control deck
- Case Control deck
- Additional Bulk Data cards:
  - CORD2R cards to define the material coordinate systems
  - GRDSET cards to constrain the redundant degrees of freedom (4, 5, and 6)
  - FORCE cards for the two loading cases
  - MAT9 material properties cards
  - PSOLID cards for the various groups of solid elements
  - SPC1 cards to impose the necessary boundary conditions
  - ENDDATA card

The printout from a NASTRAN solution run, including an echo of the completed input data decks, is presented in Appendix H. This output corresponds to the bracket model shown in Figure B-9.

SINGLE STRIP C-2 PREPROCESSOR

The C-2 model preprocessor was developed to postprocess the data generated by the C-1 preprocessor model. Its function is to extract the bulk data for a particular strip out of the multilayered full bracket model.

The user specifies the sequence number of the desired strip (parameter ISTRIP), starting from the free edge, and the total number of strips (parameter ISTRPS) that comprise the bracket model. The grid point and element ID numbers previously assigned are retained for the C-2 run.

The program reads the C-1 bulk data generated for the full bracket model and identifies and outputs the GRID, CHEXA, and CPENTA cards (the CORD2R cards are also extracted) for all layers belonging to the desired strip, which terminates at the washer opening. The corresponding part of the model on the other side of the washer opening is assumed to have no significant influence on the results because the washer is assumed to completely restrain the bracket along its circular boundary.

The C-2 model preprocessor program consists of approximately 120 FORTRAN statements (see Appendix I for the program listing). A detailed flowchart that explains the logic and sequence of program operations is presented in Appendix J.

Figure B-13 illustrates the "multilayer" input data required for the separate C-1 run necessary to produce the major input data for the C-2 preprocessor model.

Job Control Statements

The C-2 model preprocessor has a two-part JCL similar to that of the C-1 preprocessor. The first part contains the user ID and the Execute FORTRAN command, and the second part specifies the disposition of the output (save or dispose). The C-2 JCL also manages two tape units: Unit 1 (input) contains, in card format, the bulk data generated by the C-1 preprocessor for the full (multilayer, multistrip) bracket model, and Unit 2 (output) stores the bulk data extracted for the critical strip and later outputs it for NASTRAN analysis. Lines 113 through 116 of the program listing (Appendix I) show some of the job control statements, and line 117 specifies the desired strip number and the total number of strips in the bracket model. On-line disk pack WYLBUR is employed to read the specified Bulk Data cards and write the selected Data cards.

The program designates Tape Units 5 and 6 as the current input and output units, in the usual fashion.

Typical C-2 Output

This program produces two types of output: an echo of the input parameters, which is written on Tape Unit 6 and printed along with the preprocessor run, and Bulk Data cards CHEXA, CPENTA, GRID, and CORD2C, printed in typical 8-column NASTRAN format. (Note that the program assigns a PID (property ID) value of 1, 2, or 3 on the CHEXA and CPENTA cards for the bottom layer and increments by 10 for each subsequent layer above.) This bulk data is written on Tape Unit 2 (input) and saved on on-line disk pack

```
&PARAMS
T(1) = 0.01, T(2) = 0.01, T(3) = 0.01, T(4) = 0.01, T(5) = 0.01, T(6) = 0.01,
T(7) = 0.005, T(8) = 0.01, T(9) = 0.01, T(10) = .01, T(11) = .01, T(12) = .01,
T(13) = .01, LAYERS = 13, WIDTH = 0.5, HT2 = 0.4, RADIUS = 0.25, DELTY2 = 0.20,
LEGX1 = 0.27, DELTAY = 0.09, BEND = 0.125, DELTAT = 15.0, LEGY = 0.17,
DELTAZ = 0.17, DELTAX = 0.1, TOLER = 0.015
& END
```

NOTES:

1. COLUMN 1 MUST BE BLANK FOR ALL PARAM CARDS.
2. &PARAMS IS ENTERED IN COLUMNS 2-8 AND &END IN COLUMNS 2-5.
3. THE VALUES OF PARAMETERS HAVE FORMAT F8.4; THUS, THERE SHOULD BE NO MORE THAN THREE DIGITS TO THE LEFT OF THE DECIMAL AND NO MORE THAN FOUR DIGITS TO THE RIGHT.
4. ALL 13 PARAMETERS AND ONE THICKNESS PER LAYER MUST BE SPECIFIED; THE DEFAULT VALUE FOR LAYERS EQUALS 1.

Figure B-13. Sample Input Data for Multilayer C-1 Model Preprocessor Run

WYLBUR, as previously described, and additional data 's appended for the subsequent NASTRAN run. The program listing and output are shown in Appendix K.

SINGLE STRIP NASTRAN

In order to conduct a single strip NASTRAN , the Bulk Data cards generated by the C-2 model preprocessor must be supplemented with suitable Executive Control and Case Control decks and Bulk Data cards that define the boundary conditions and material properties.

Boundary Conditions

Three types of boundary conditions must be imposed:

- The grid points lying on the exposed surfaces (top and bottom) must be subjected to the same constraints as they were during the C-1 model analysis. These constraints are effected by including the appropriate SPC (or SPC1) and GRDSET cards.

- The rest of the grid points on exposed surfaces, which were unconstrained during the C-1 model analysis, are subjected to the same finite displacements (T1, T2, T3) as during the corresponding C-1 model analysis. This condition is effected by including the appropriate SPC cards.

- The interior grid points newly produced by the multilayered construction are interlinked to the exterior grid points by continuous RSPLINE elements along all the straight lines across the thickness of the bracket. It was assumed that RSPLINE elements would provide a more realistic boundary condition for the single strip analysis (than MPC or RBE elements), and the few test runs carried out confirmed this assumption.

Note that no loads need be applied for this analysis; the model is deformed under the influence of displacement boundary conditions.

Material Properties

The number of MAT9 cards required equals the number of types of layers that comprise the angle bracket. The number of PSOLID cards required equals the number of sets of PID values assigned to the various CHEXA and CPENTA elements by the C-1 preprocessor program. Three groups of PID values corresponding to three parts of the angle bracket are shown in Figure B-14.

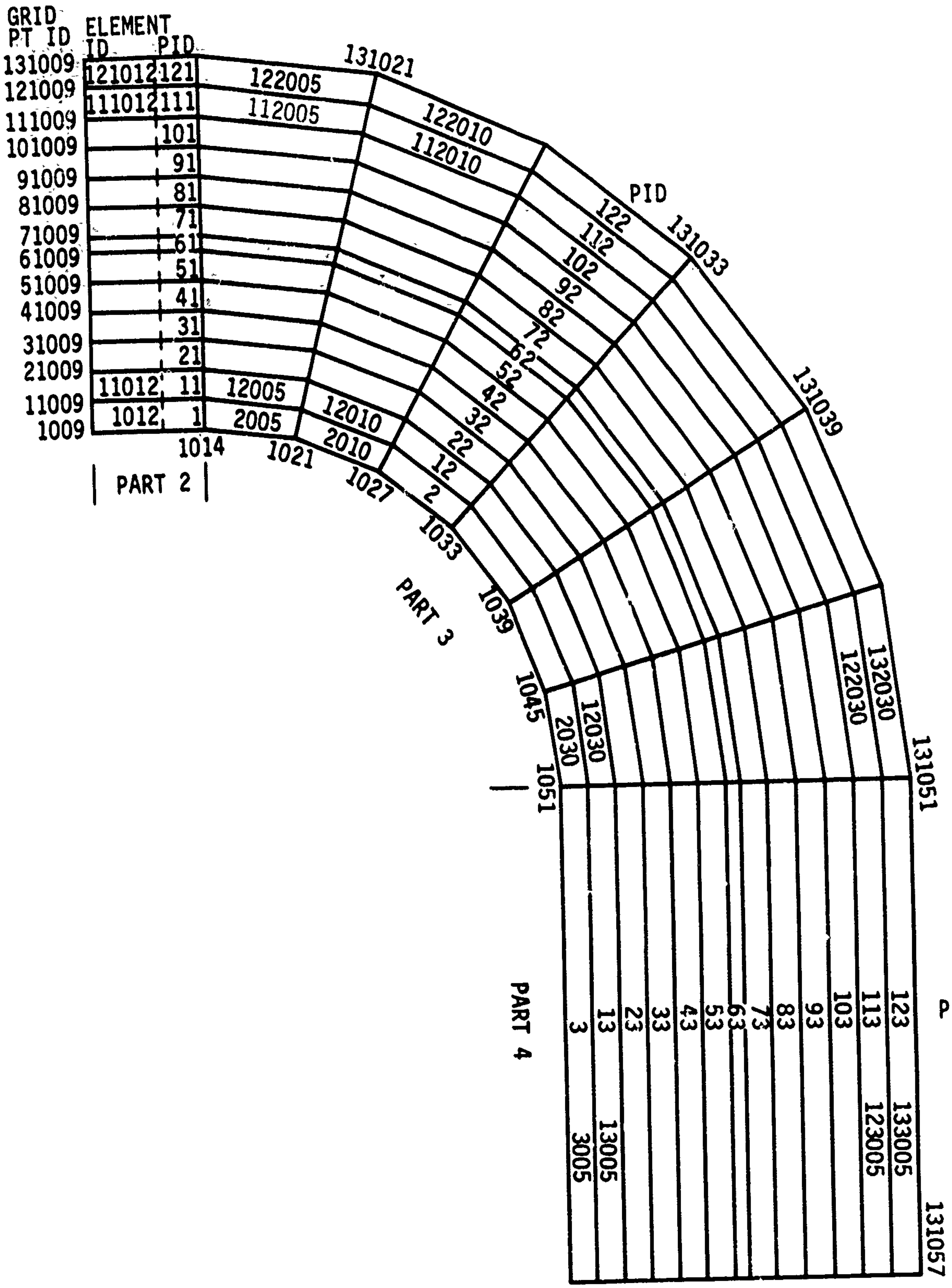


Figure B-14. Critical Strip Model

Dummy Elements

Since all grid points in the single strip model are subjected to either a single- or multipoint constraint, NASTRAN would be unable to initiate execution without a valid A-SET matrix. Three CBAR elements are input to define the additional grid points required.

C-2 Data Check and Plot Run

The output produced by a NASTRAN data check and plot run and the undeformed plots produced are shown in Appendix L.

NASTRAN C-2 Solution Run

To conduct a NASTRAN solution run, the bulk data generated by the C-2 model preprocessor must be supplemented with the following cards:

- NASTRAN wavefront optimization card (PREOPT = 1)
- Executive Control deck
- Case Control deck
- Additional Bulk Data cards:
  - CORD2R cards to define the material coordinate systems
  - GRDSET cards to constrain the redundant degrees of freedom (4, 5, and 6)
  - Additional GRID, CBAR, PBAR, and MAT1 cards to provide for the required dummy elements
  - MAT9 material properties cards
  - PSOLID cards for the various groups of solid elements
  - SPC, SPC1, and RSPLINE cards to impose the necessary boundary conditions
  - ENDDATA card

Part of the printout from a NASTRAN C-2 solution run, including an echo of the completed input data checks, is presented in Appendix M. This example corresponds to the angle bracket shown in Figure B-9.

NASTRAN RESULTS

Throughout this study T300 graphite/5208 epoxy was used for the test case. The stacking sequence $[0_\#/45_\#/0_\#]$ was used, where the symbol # stands for crossplied fabric. Two load cases were examined: a uniform tension load and a uniform clockwise couple. The sample ten-strip model executed by the NASTRAN plotter is shown in Figure B-15. The following geometries were used:

T_i = thickness of the i^{th} lamina (0.14 inch TYP)

R_b = bend radius (0.125 inch)

R_w = washer radius (0.219 inch)

D_{wt} = distance from the center of the washer to the tangent line (0.249 inch)

D_{ew} = distance from the free transverse edge to the center of the washer (0.40 inch)

D_{lt} = distance from the transverse loaded edge to the closest tangent line (0.249 inch)

Width = width of the modeled half-symmetrical bracket (1.0 inch)

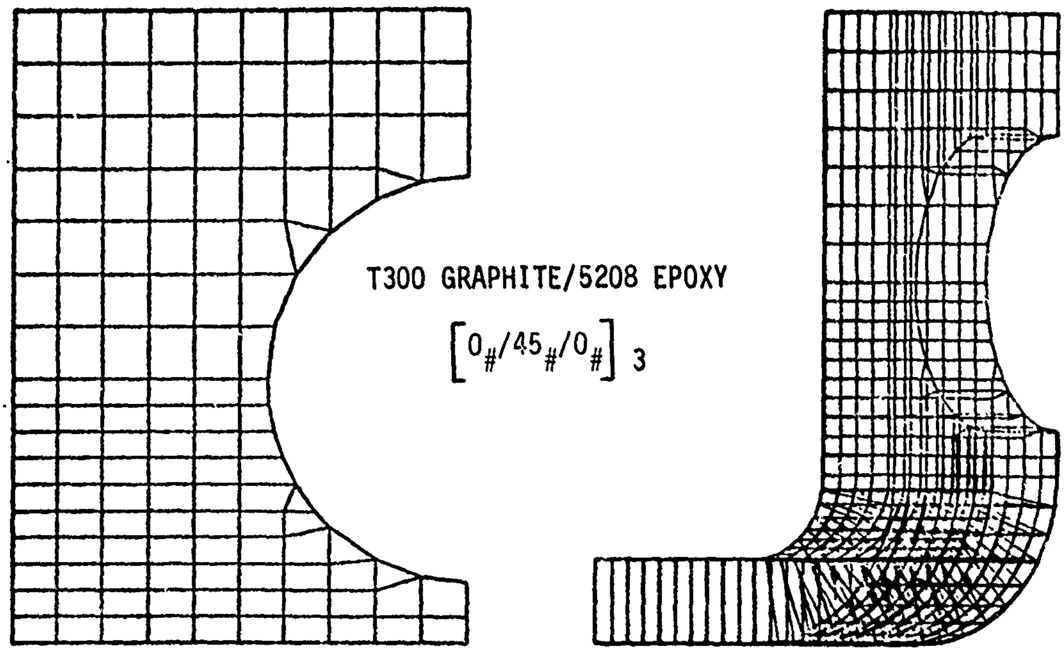


Figure B-15. Sample Ten-Strip Model

Using the C-1 model preprocessor, the NASTRAN data output from the uniform tension load case was plotted in such a way that it could easily be compared with data derived from mathematical theory.

In Figure B-16 the tangential stress σ_y/σ_0 is plotted versus bend angle along the centerline strip; it is most critical at the inner surface and its gradient peaks at θ = 75 to 85 degrees. Interlaminar shear stress is also expected to be most critical at this location. (All stresses plotted in these figures have been normalized.)

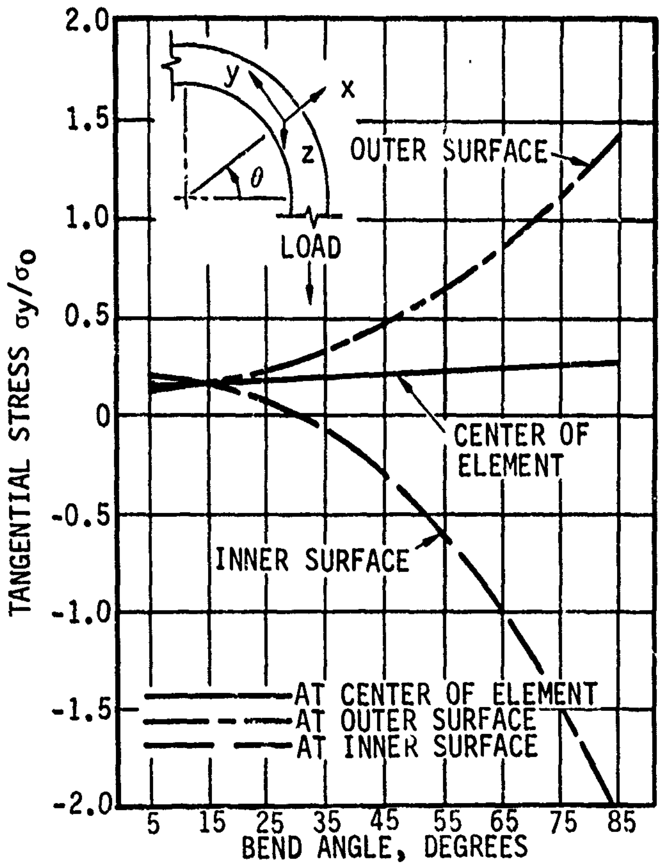


Figure B-16. Tangential Stress Versus Bend Angle Along the Centerline Strip: Uniform Tension Load Case

In Figure B-17 this same stress is plotted versus angle width at θ = 85 degrees (angle of maximum stress). This stress and its gradient (slope) appear to peak at the inner surface and closest to the centerline of the angle.

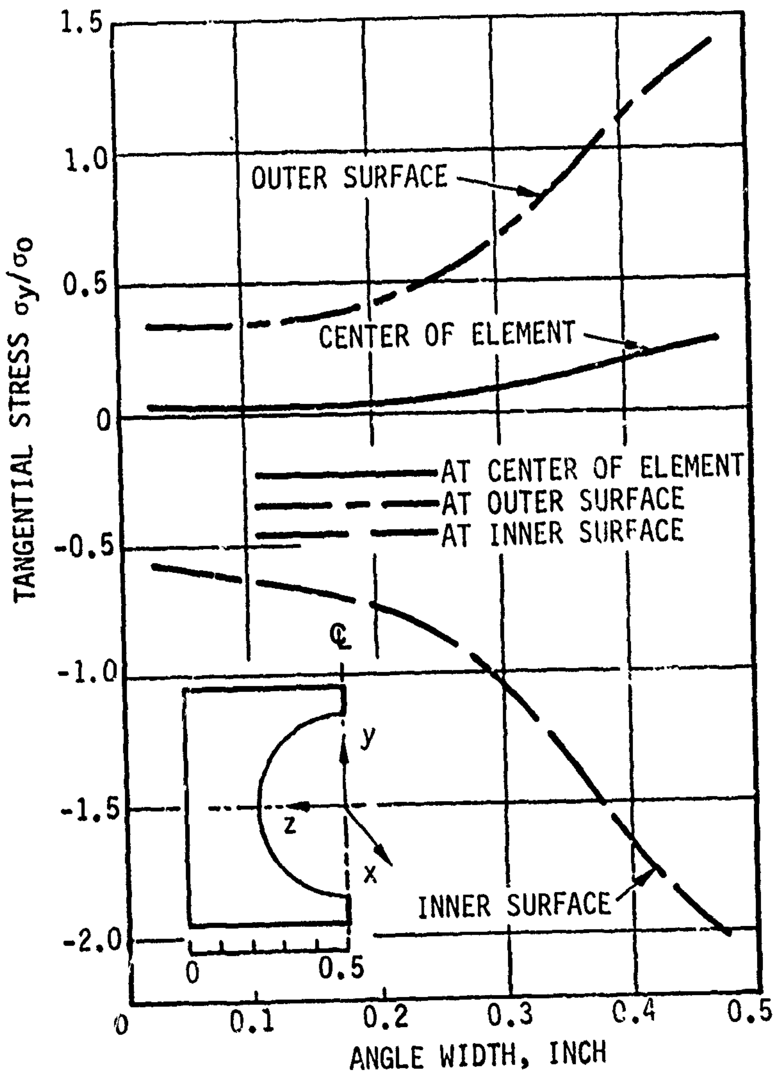


Figure B-17. Tangential Stress Versus Angle Width: Uniform Tension Load Case

In Figure B-18 the interlaminar shear stress τ_{xy}/σ_0 is plotted versus bend angle. The shear stress reaches a maximum at θ = 85 to 90 degrees and remains relatively constant across the thickness of the laminate as evidenced by the positive correlation of the curves.

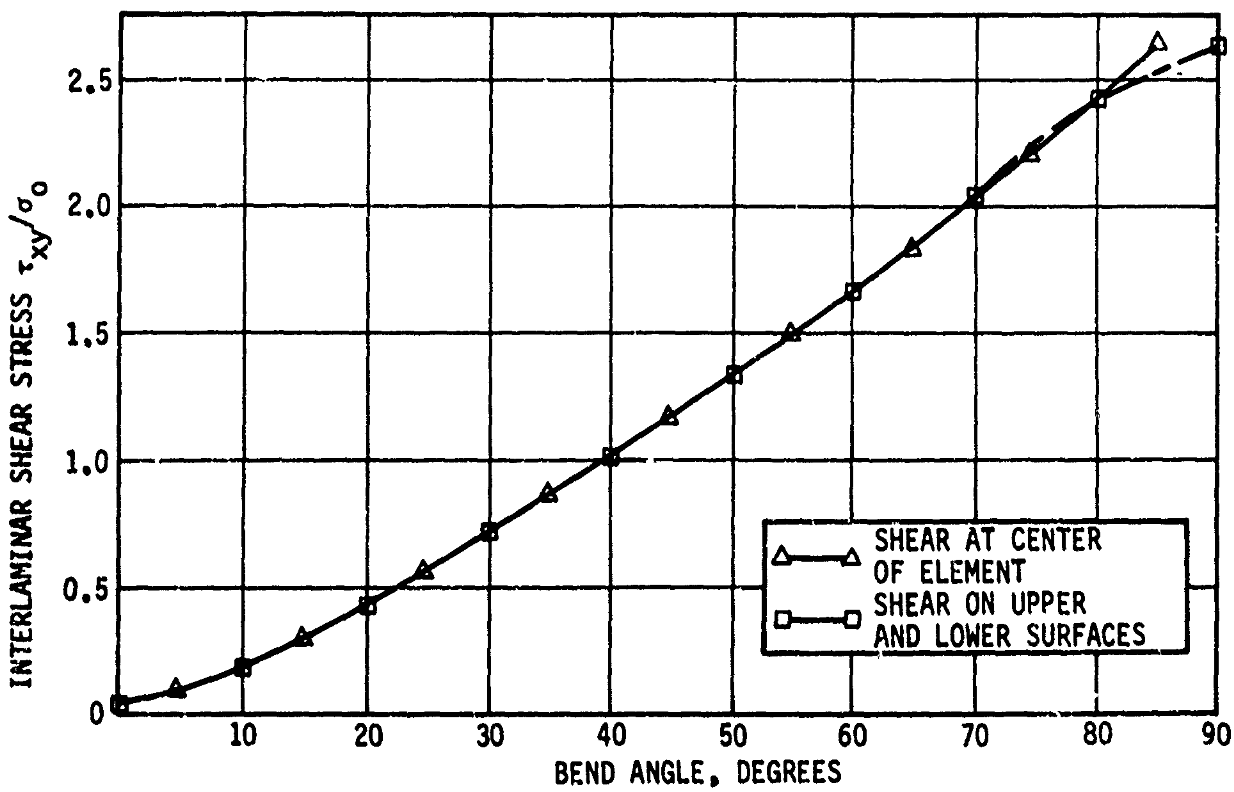


Figure B-18. Interlaminar Shear Stress Versus Bend Angle: Uniform Tension Load Case

In Figure B-19 this same stress is plotted versus angle width at the angles indicated. At θ = 5 degrees, the stress is maximum at the edge of the angle and decreases toward the centerline. At all other angles, the stress increases to a maximum at the centerline. The transverse shear strength τ_{xz} is directly proportional to the interlaminar shear strength.

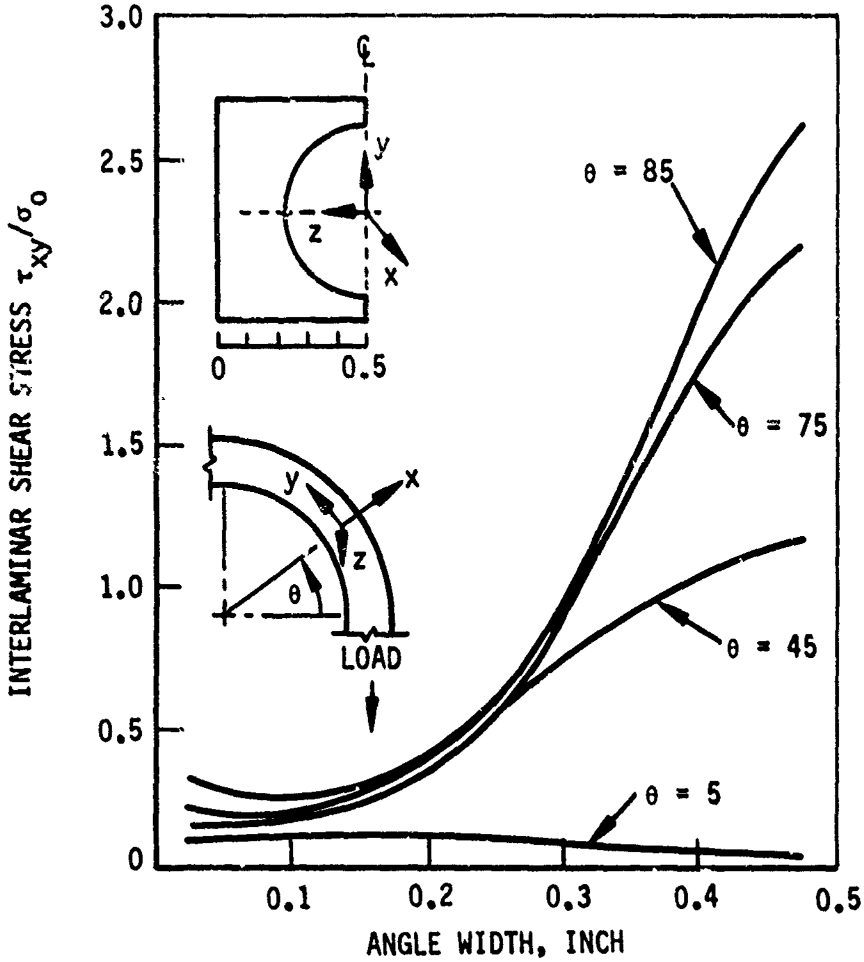


Figure B-19. Interlaminar Shear Stress Versus Angle Width: Uniform Tension Load Case

The normal stress (normal to the laminate surface) σ_x/σ_0 is plotted versus bend angle in Figure B-20. In general, this is a compression field; however, at bend angles up to θ = 15 degrees a low-magnitude tension field is present near the centerline of the angle (Figure B-21). Interlaminar tension can only occur in the flat area between the applied load and the bend angle, acting perpendicular to the applied load.

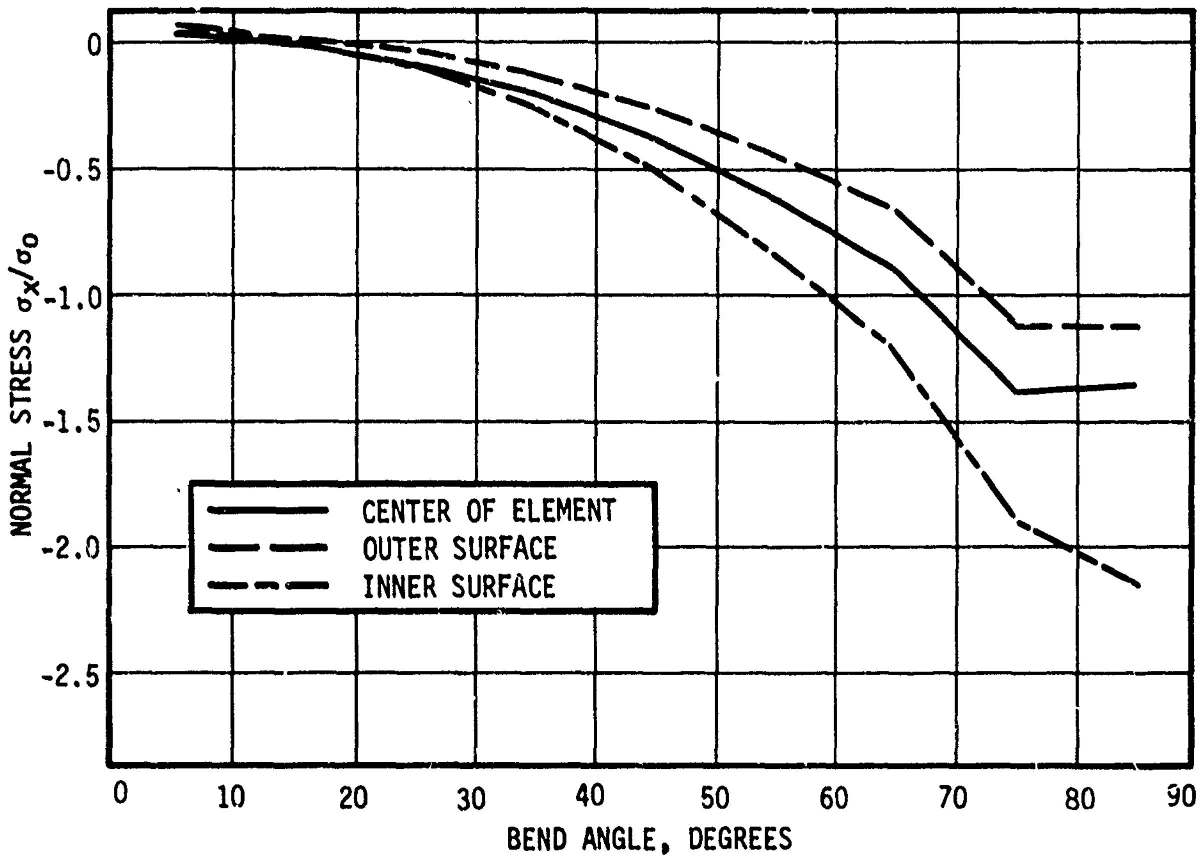


Figure B-20. Normal Stress Versus Bend Angle: Uniform Tension Load Case

Up to this point the C-1 model has been used to study the displacement/load distribution by measuring the stresses and their gradients. In reducing the data, the study was focused on the areas of primary interest, the locations at which a delamination could begin.

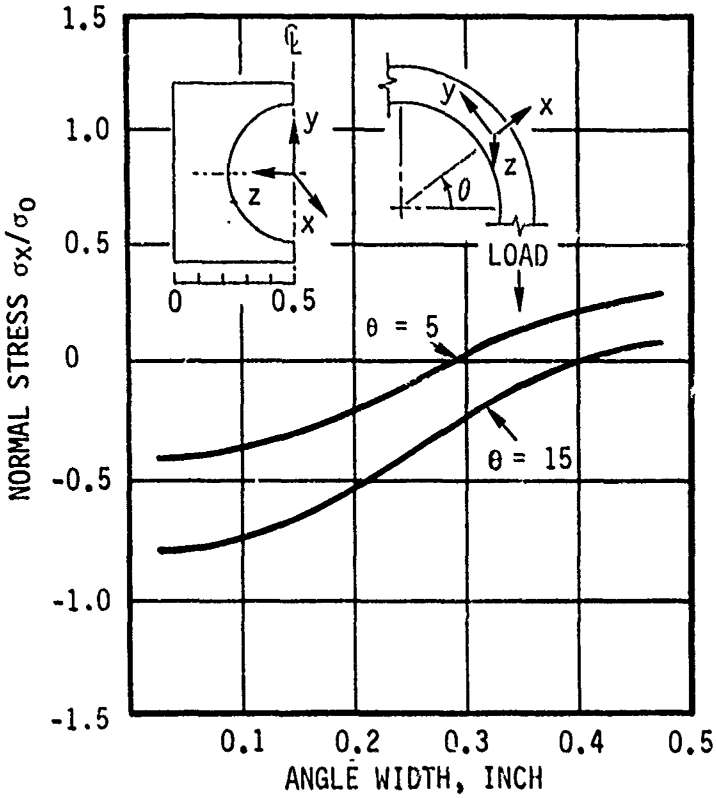


Figure B-21. Normal Stress Versus Angle Width: Uniform Tension Load Case

To determine the magnitude of the interlaminar stresses, a C-2 run was executed on the centerline strip of the ten-strip test model (see Figure C-22). Interlaminar stress analyses can be carried out on any layer or, in some cases, the entire model can be analyzed layer by layer. In some instances more than one lamina of the same type with the same orientation are lumped together into a single layer to reduce computer costs.

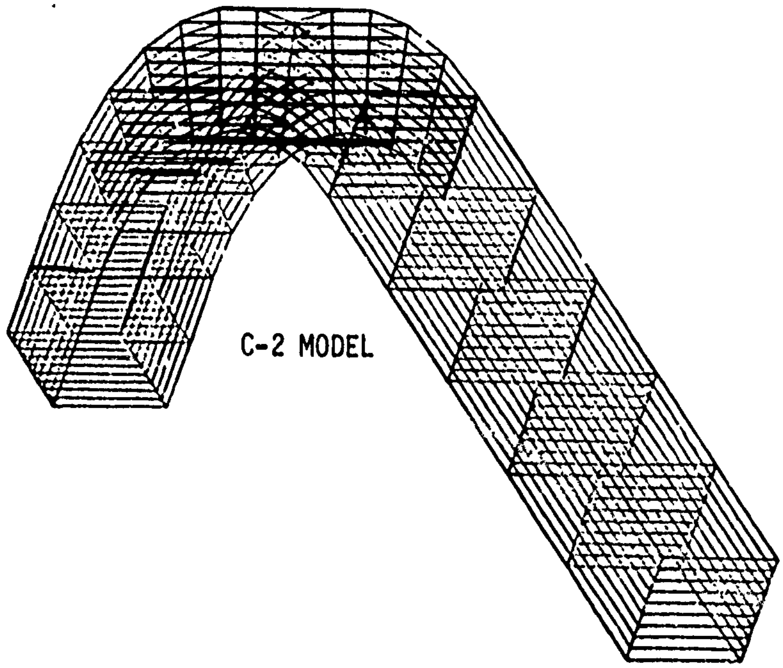


Figure B-22. Laminated Centerline Strip of the Ten-Strip Test Model

The interlaminar shear stress τ_{xy}/σ_0 along the bend angle is shown for all nine laminae in Figure B-23. The lamina nearest the inner surface is identified as L0, the next is L1, and the lamina nearest the outer surface is L8. Zero-degree crossplied fabric laminae are represented by the even numbers (and zero), and the 45-degree crossplied fabric laminae are represented by the odd numbers. The interlaminar shear stress peaks between the L0 and L1 laminae at θ = 75 degrees.

$$\left(\frac{\tau_{xy}}{\sigma_0}\right)^{L0,\ L1} = \left[\left(\frac{\tau_{xy}}{\sigma_0}\right)^{L0} + \left(\frac{\tau_{xy}}{\sigma_0}\right)^{L1}\right] \Big/ 2$$

$$\left(\frac{\tau_{xy}}{\sigma_0}\right)^{L0,\ L1} = \left[5.40 + 3.64\right] \Big/ 2 = 4.52$$

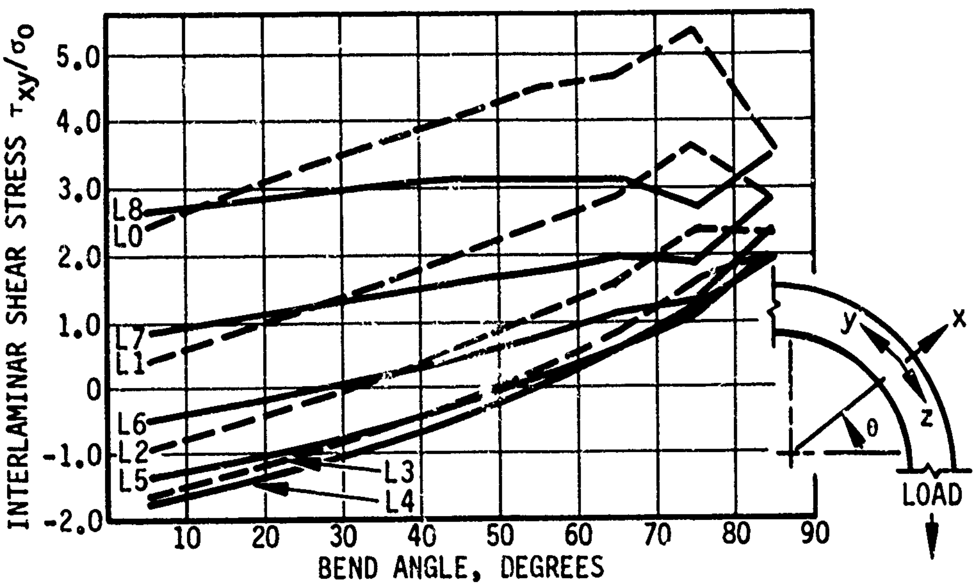


Figure B-23. Interlaminar Shear Stress Versus Bend Angle: Uniform Tension Load Case

In Figure B-24 the interlaminar shear stress through the laminate thickness is shown at θ = 5 and 75 degrees. These stresses are very nearly equal at the outer surface.

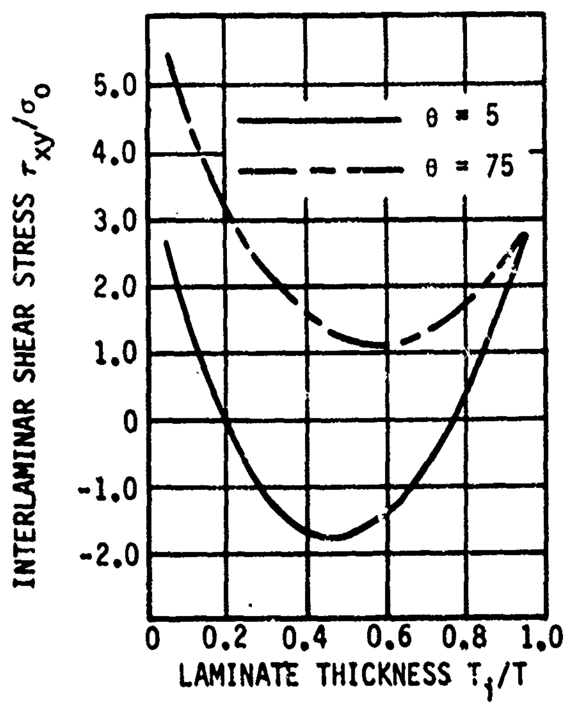


Figure B-24. Interlaminar Shear Stress Through the Laminate Thickness at θ = 5 and 75 degrees: Uniform Tension Load Case

Normal stress along the bend angle is shown in Figure B-25. This stress is chiefly in compression, but it is in tension up to about $\theta = 15$ degrees. In the flat region up to $\theta = 0$ degrees, this stress is maximum and is

$$\left(\frac{\sigma_x}{\sigma_0}\right) = 0.1333$$

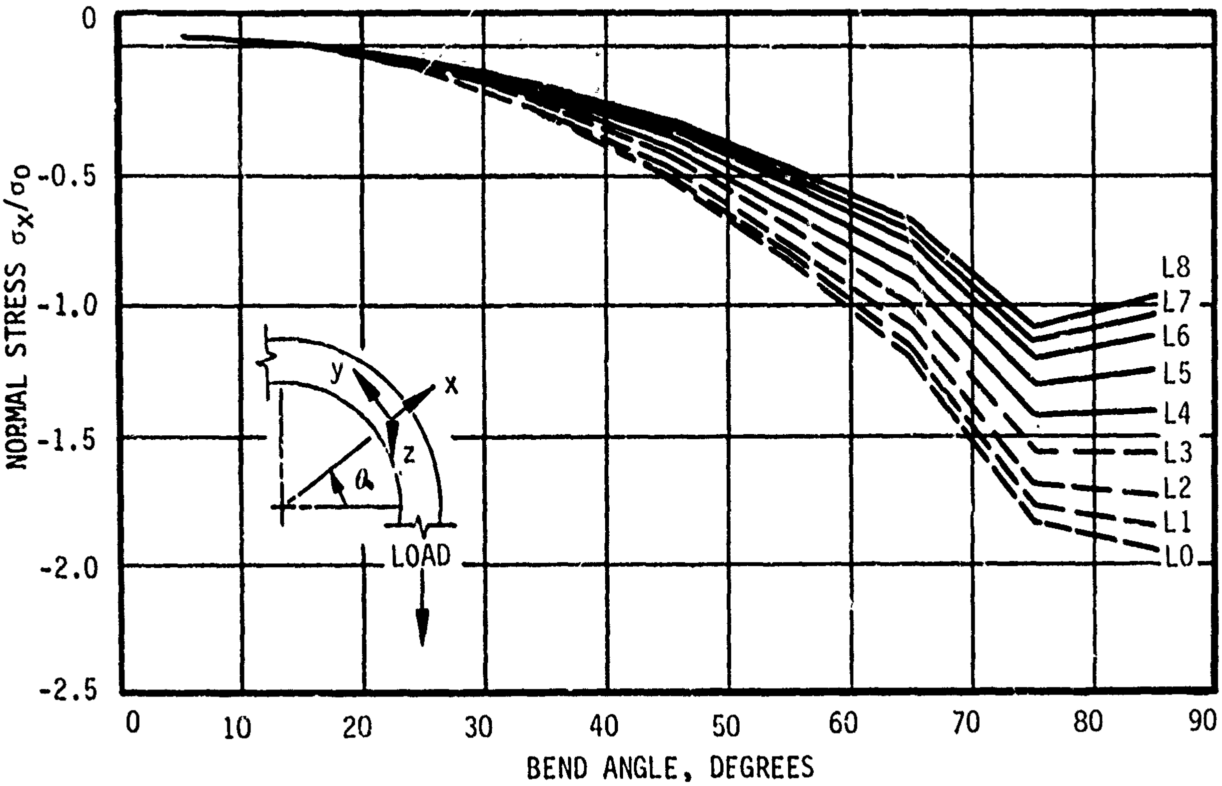


Figure B-25. Normal Stress Along the Bend Angle: Uniform Tension Load Case

Normal stress along the centerline strip is shown at θ = 5 and 75 degrees in Figure B-26. At θ = 5 degrees this stress is an interlaminar tension with a magnitude of approximately 0.05.

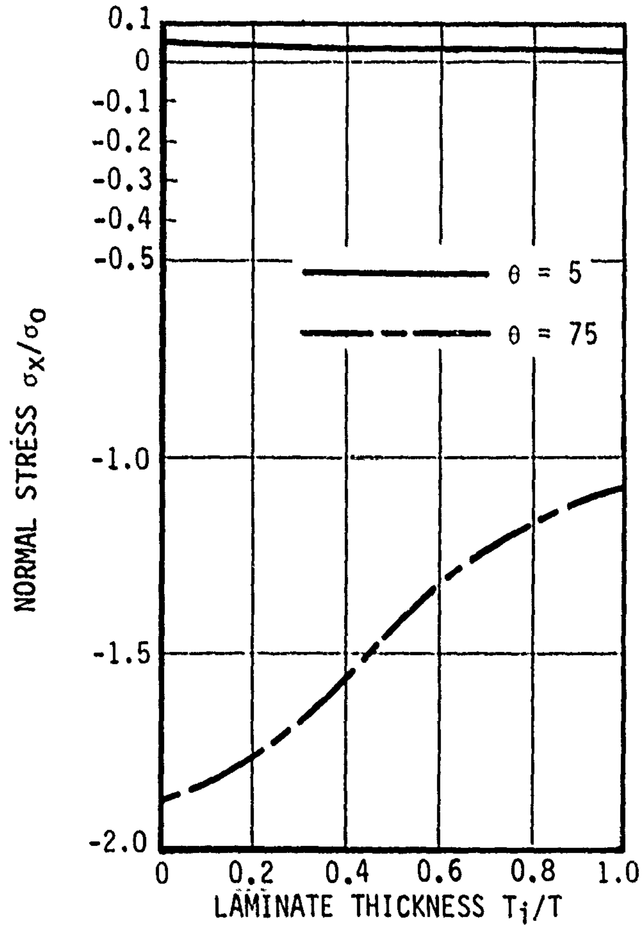


Figure B-26. Normal Stress Through the Laminate Thickness at θ = 5 and 75 degrees: Uniform Tension Load Case

Uniform clockwise couple load cases were also run using the C-2 preprocessor model. Interlaminar shear stresses are plotted versus bend angle in Figure B-27. This stress, which peaks at θ = 0 to 5 degrees, has a magnitude of

$$\left(\frac{\tau_{xy}}{\sigma_0}\right)^{L0,\ L1} = \left(0.446 + 1.580\right)/2 = 1.013$$

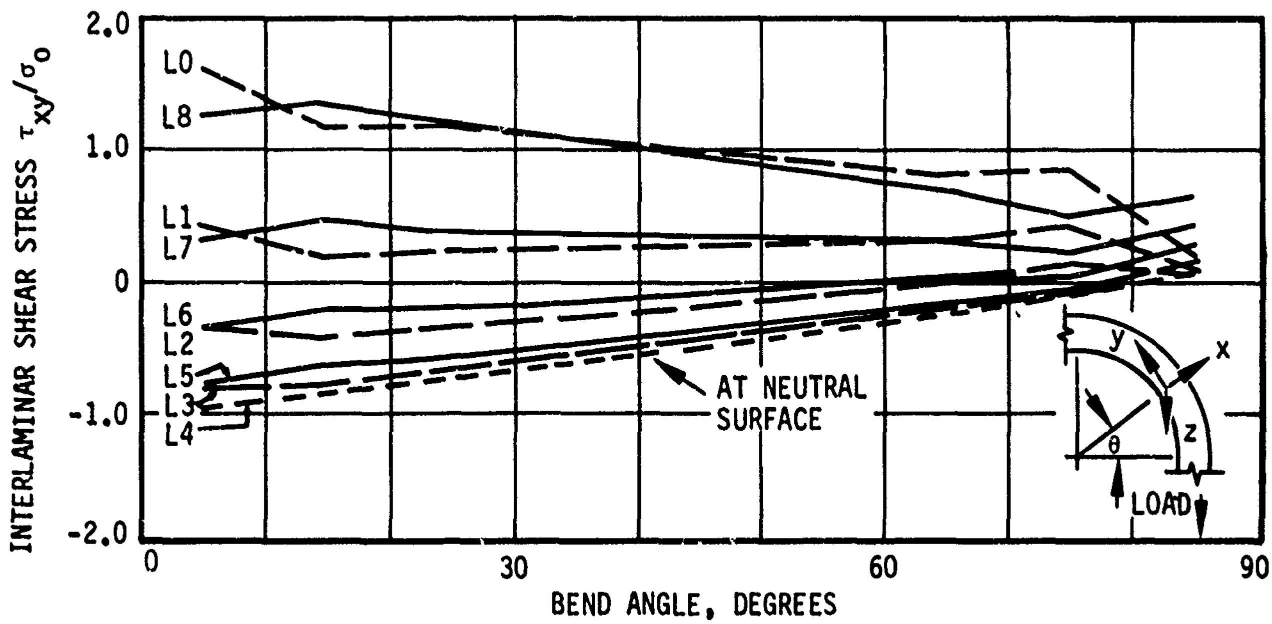


Figure B-27. Interlaminar Shear Stress Versus Bend Angle: Uniform Clockwise Couple Load Case

Normal stress is plotted versus bend angle in Figure B-28. This stress, a compression field, is rather uniform all along the bend angle.

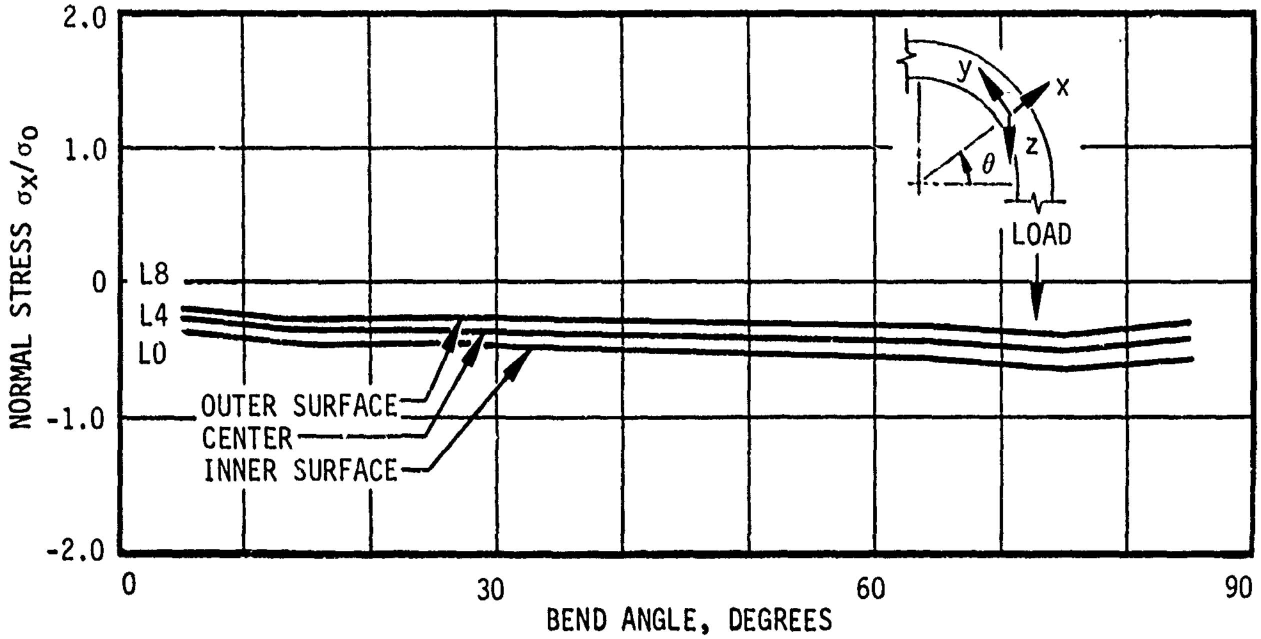


Figure B-28. Normal Stress Versus Bend Angle: Uniform Clockwise Couple Load Case

PARAMETRIC STUDIES

Parametric studies were conducted using the C-1 preprocessor model to determine the influence of various design parameters (Table B-2). The finite element model used for these studies varied somewhat from that described previously; five strips were used instead of ten. This coarser grid gave results comparable with those obtained using the ten-strip model, at one-fourth the cost in computer time.

The parametric study was based on the behavior of the in-plane tangential stress gradient $\partial\sigma_y/\partial(r\theta)$ and the interlaminar shear stress τ_{xy}, which determines interlaminar shear stress recovery. Tangential stress σ_y/σ_0 is plotted versus bend angle for varying thickness-to-bend radius ratios in Figure B-29. It can be seen that the tangential stress gradient decreases with increasing thickness-to-bend radius ratio; therefore, the larger the laminate thickness and the lower the bend radius, the smaller the interlaminar shear stress.

TABLE B-2. PARAMETRIC ANALYSIS

Run Number	Bend Radius, inch	Thickness, inch	Washer Radius, inch	Stacking Sequence	D_{lw}, inch	D_{wt}, inch	$\Delta\theta$, degrees	D_{et}, inch
1	0.25	0.125	0.25	$[0_{17}/\pm45_8]$	0.4	0.27	15	0.51
2	0.50							
3	0.125		0.219	$[0_\#/45_\#/0_\#]_3$		0.249		0.249
4			0.25	$[0_{17}/\pm45_8]$		0.27		0.51
5		0.25						
6		0.50						
7		0.125		$[0_9/\pm45_{16}]$				
8				$[0_{13}/\pm45_{12}]$				
9				$[0]$				
10				$[\pm45]$				

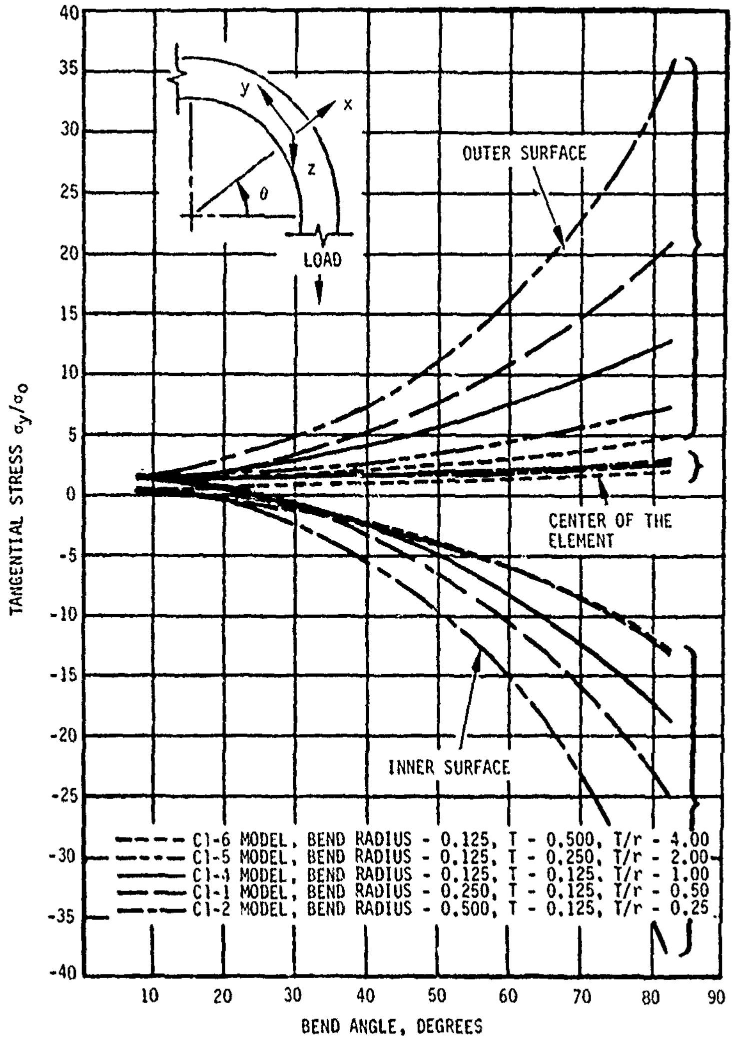


Figure B-29. Tangential Stress Versus Bend Angle for Varying Thickness-to-Bend Radius Ratios: Uniform Tension Load Case

Tangential stress is plotted versus bend angle for varying stacking sequences (with all laminae 0.125 inch thick) in Figure B-30. This stress and its gradient peak at the inner surface (θ = 75 to 85 degrees). The slope of the gradient is lowest for a 0-degree laminate and highest for a ±45-degree laminate; however, tangential stress itself is highest for a 0-degree laminate. All other stacking sequences fall in between the extremes. A laminate may be chosen based on these curves, but the minimum thickness for a given application may depend on other, more important criteria.

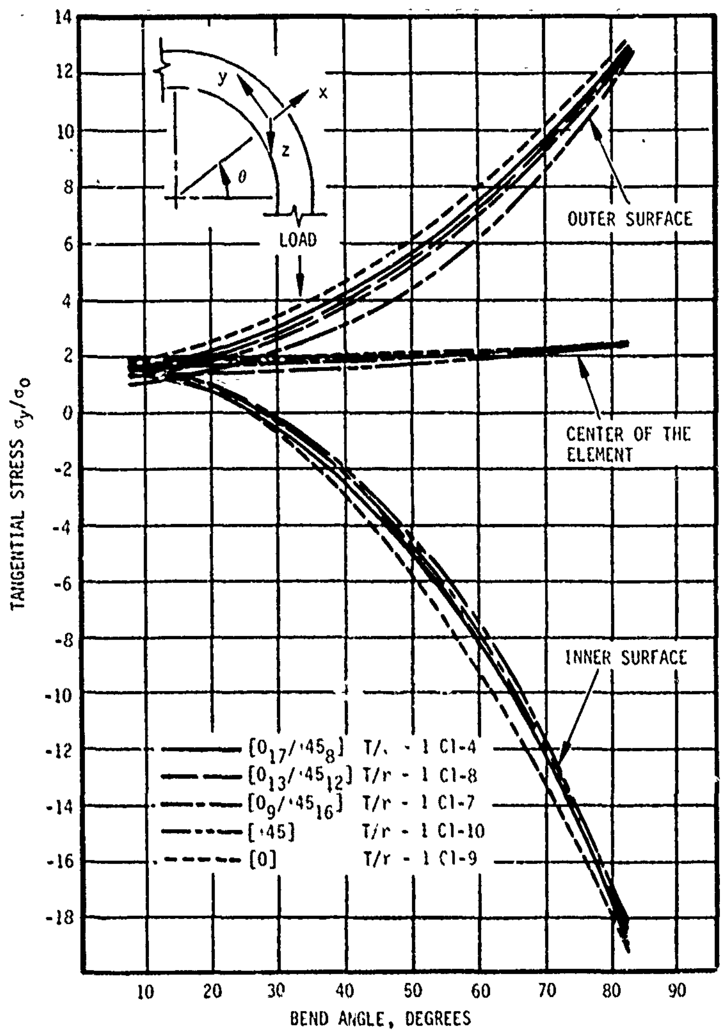


Figure B-30. Tangential Stress Versus Bend Angle for Varying Stacking Sequences: Uniform Tension Load Case

Interlaminar shear stress is plotted versus bend angle as a function of thickness-to-bend radius ratio in Figure B-31. At a bend angle of 90 degrees, this stress decreases with increasing thickness-to-bend radius ratio. For a ratio of 1, the stress varies linearly along the bend angle and, up to about 77 degrees, is the highest shown (note that the gradient is minimal at 77 degrees). For most design purposes, therefore, the thickness-to-bend radius ratio should be as high as possible.

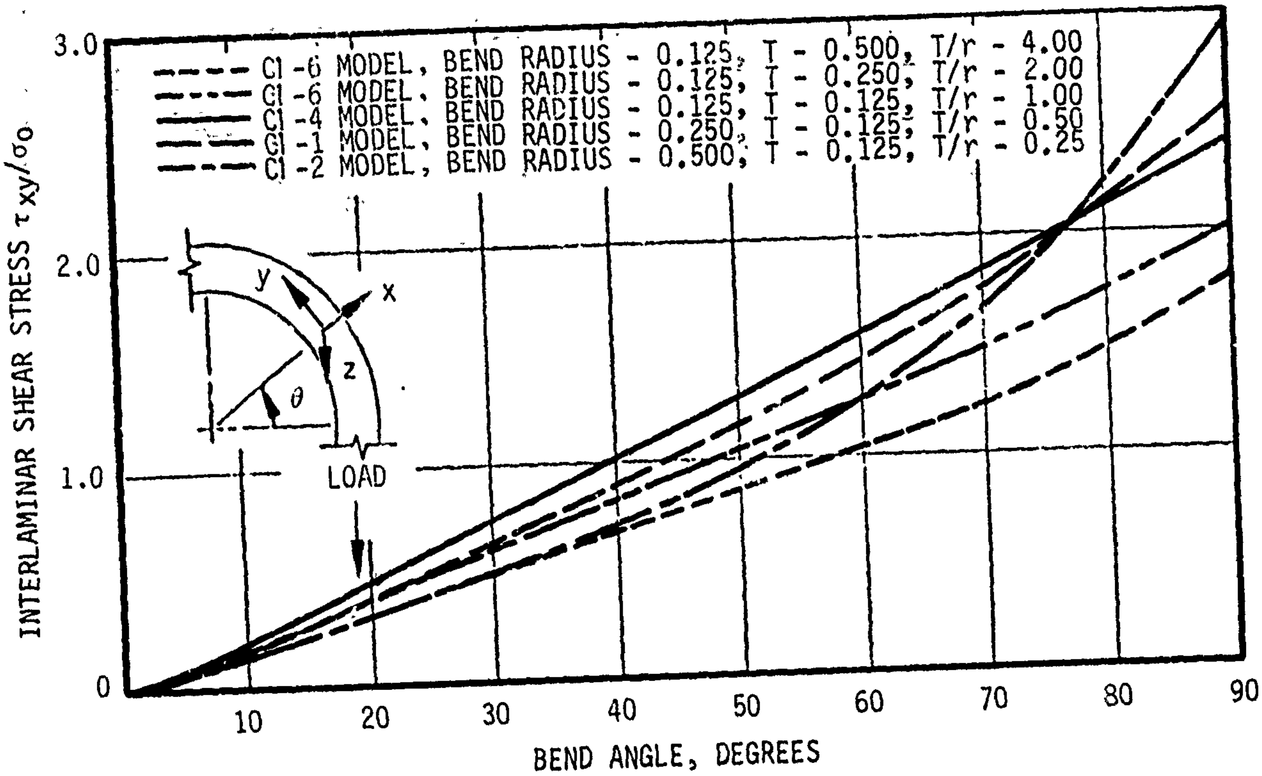


Figure B-31. Interlaminar Shear Stress Versus Bend Angle for Varying Thickness-to-Bend Radius Ratios: Uniform Tension Load Case

Interlaminar shear stress τ_{xy}/σ_0 is plotted versus bend angle in Figure B-32. For bend angles between 0 and 77 degrees, the shear stress is highest for a 0-degree laminate and lowest for a ±45-degree laminate, with the 0/±45 degree laminates falling in between. For bend angles between 77 and 85 degrees, the order reverses such that the peak shear stress, which occurs at θ = 85 degrees, is highest for a ±45-degree laminate and lowest for a 0-degree laminate.

For the $[0_{13}/\pm45_{12}]$ laminate, which corresponds to the quasi-isotropic laminate, the interlaminar shear stress gradient is constant throughout the range.

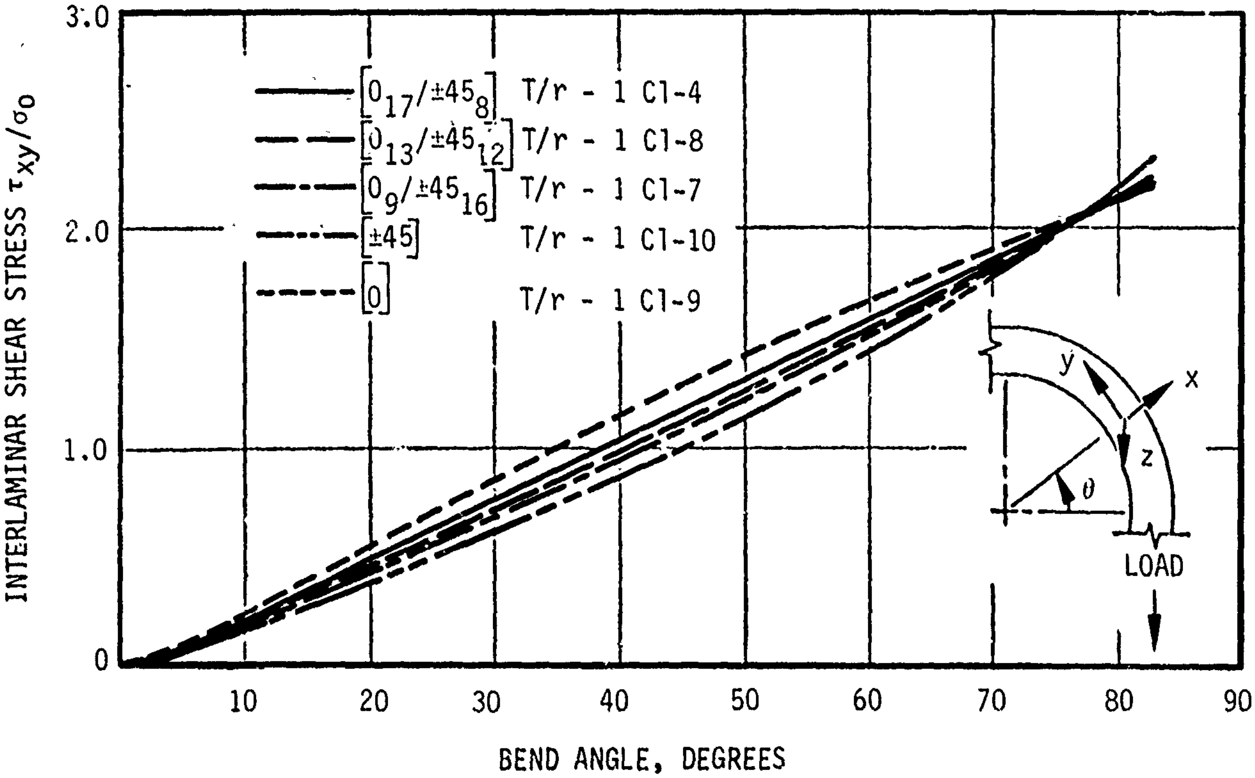


Figure B-32. Interlaminar Shear Stress Versus Bend Angle for Varying Stacking Sequences: Uniform Tension Load Case

A C-2 model analysis was performed to determine the influence of the lamina stacking sequence on interlaminar stresses. The model consisted of a 25-ply laminate of T300 graphite/5208 epoxy. The critical strip, which was extracted from the previous ten-strip C-1 model, was 0.1 inch wide. Four stacking sequences were studied (Figure B-33).

Interlaminar shear stress is plotted across the laminate thickness for the four stacking sequences in Figure B-34. Interlaminar shear stress is independent of the stacking sequence over most of the laminate thickness; in fact the only discernible difference among the four stacking sequences occurs near the outer surface, where Sequence 3 appears to show a slightly lower stress value.

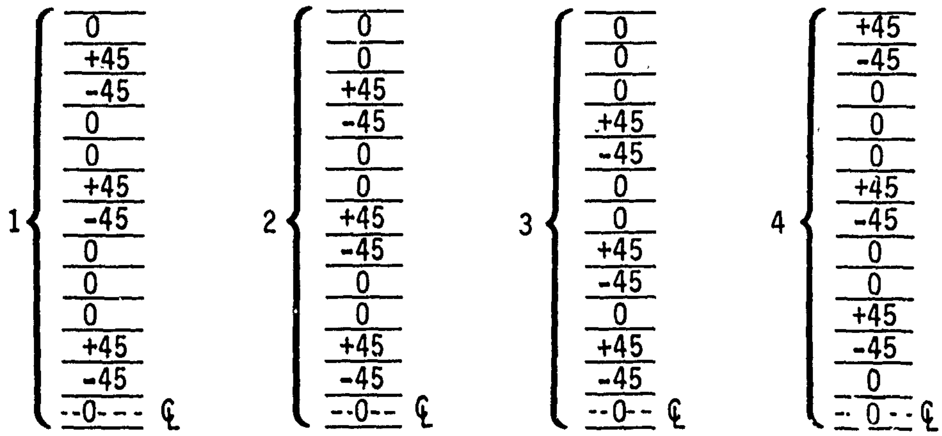


Figure B-33. Four Stacking Sequences

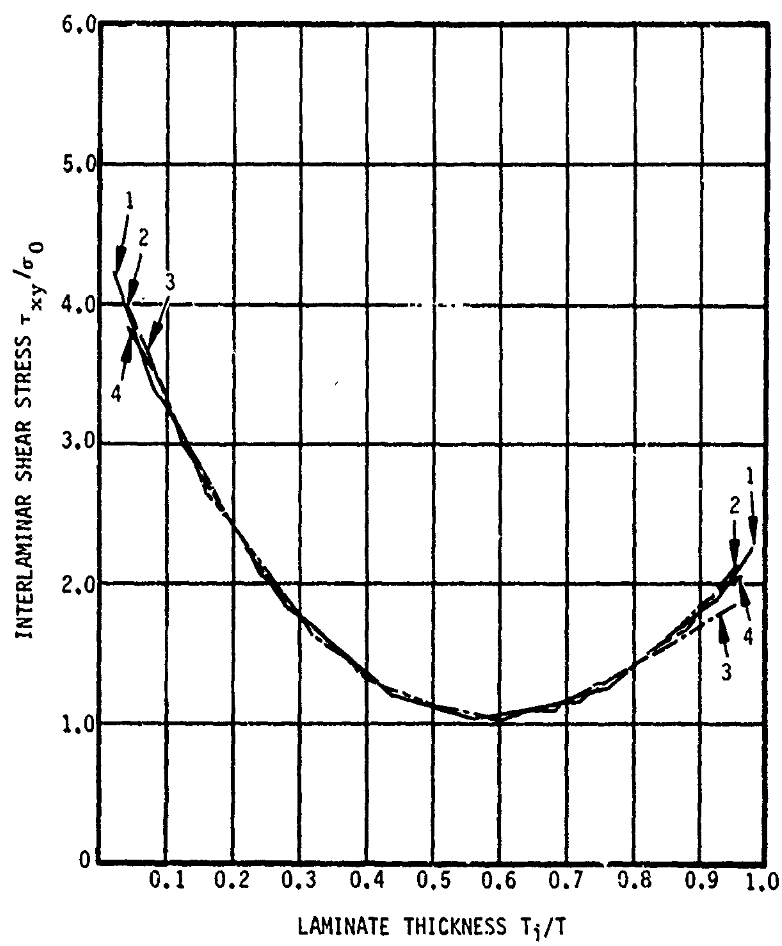


Figure B-34. Interlaminar Shear Stress for Varying Stacking Sequences Through the Laminate Thickness

To verify the importance of the type of laminae used (fabric or tape), a comparison was made between the four configurations shown in Figure B-33 and a $[0_{\#}/45_{\#}/0_{\#}]$ laminate. The fabric laminate coincides with the others for laminates between 0.5 and 0.65 inch thick; however, for all other thicknesses it is subjected to much higher interlaminar shear stress levels. This indicates that the choice of material would be tape.

It should be noted, however, that mixing is very important in keeping the stresses uniformly distributed throughout the laminate thickness. Stress gradients are highly sensitive to induced singularities due to any severe change in laminae properties within a laminate.

EXPERIMENTAL TESTS

The graphite, Kevlar 49, S-glass, and E-glass composite angle specimens described in Table B-3 were fabricated and tested after 3 to 4 days in the normal laboratory environment. The tension test setup for these 1-inch-wide specimens is shown in Figure B-35.

Both incipient local matrix failure by delamination in the outer plies of the corner region and ultimate filament fracture were recorded. Initial matrix delaminations were audible and were measured as sudden changes in the slope of the load-deflection curve. These changes of slope were recorded in two ways:

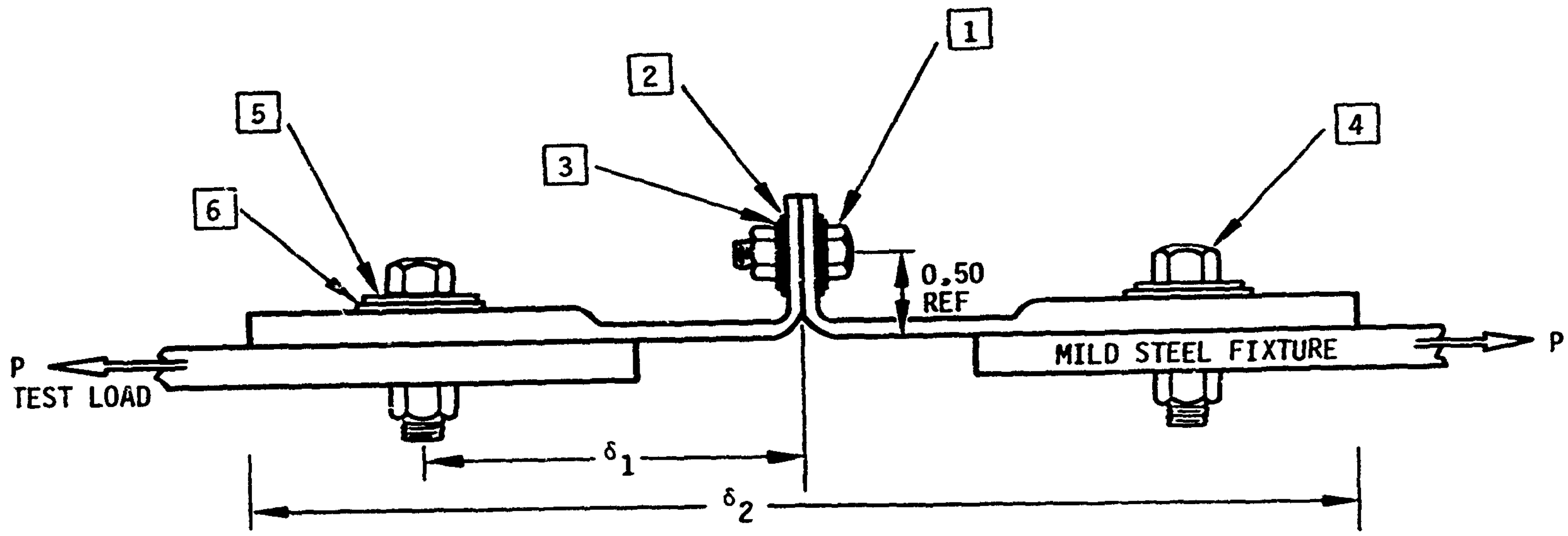
- Displacement from top of grip to mid-bolt head (Delta 1)
- Test machine head travel (Delta 2)

As shown in Figure B-35, Delta 2 readings have more than twice the magnitude of the Delta 1 readings in the elastic range. Delta 1 readings were recorded continuously and automatically, and Delta 2 readings were taken (from the gauges) every 20 pounds for the -1, -3, and -5 specimens and every 40 pounds for the -2, -4, and -6 specimens.

The typical sequence of events in fracture failures is illustrated in Figure B-36. The corners of thinner angles straighten out elastically for a distance of up to two or three times their initial radii. Next the matrix fails in delamination, and finally the fibers fracture at ultimate load.

TABLE B-3. ANGLE TENSION TEST SPECIMENS

Panel No.	Quantity Made	Fiber Type	Supplier Designation	Ply Thickness, inch	Stacking Sequence	Cured Thickness, inch
1	8	Graphite	Hexcel F3T-584, Gr/F-250	0.0125	$[(0/90)/(\pm45)/(0/90)]_3$	0.078
2	8	Graphite	Narmco Rigidite, T300/5208	0.014	$[(0/90)/(\pm45)/(0/90)]_5$	0.205
3	8	Kevlar 49	Hexcel 181, Kevlar 49/F-155	0.0095	Same as 1	0.085
4	8	Kevlar 49	Narmco 281, Kevlar 49/5208	0.009	Same as 2	0.124
5	8	S-glass	Hexcel 181, S2-glass/F-155	0.0095	Same as 1	0.084
6	8	E-glass	Narmco 7781, E-glass/5208	0.010	Same as 2	0.156



[1] NAS 1103 OR NAS 1223-4 OR EQUIVALENT NO. 10-32 HEX HEAD BOLTS WITH ¼- TO ½-INCH GRIP; NAS 671-10 OR NAS 1021 OR EQUIVALENT PLAIN HEX NUTS TO BE TORQUED TO 26 IN.-LB

[2] FIGERGLASS, GRAPHITE/EPOXY, TEFLON, OR TEDLAR WASHER, 0.2-INCH ID, 1/2- TO 3/4-INCH OD IN 2 PLACES, 1/32- TO 3/32-INCH THICK

[3] NAS 620 OR EQUIVALENT NO.10 ID STEEL PLAIN WASHER, TYP OF 2 PLACES

[4] 1/4-20 OR 1/4-28 BOLT AND NUT, TORQUED TO 3/4 OF ALLOWABLE, TYP OF 2 PLACES

[5] PLAIN STEEL WASHER [6] FIBERGLASS, GRAPHITE/ /EPOXY, OR GLASS/TEFLON WASHER

Figure B-35. Test Setup

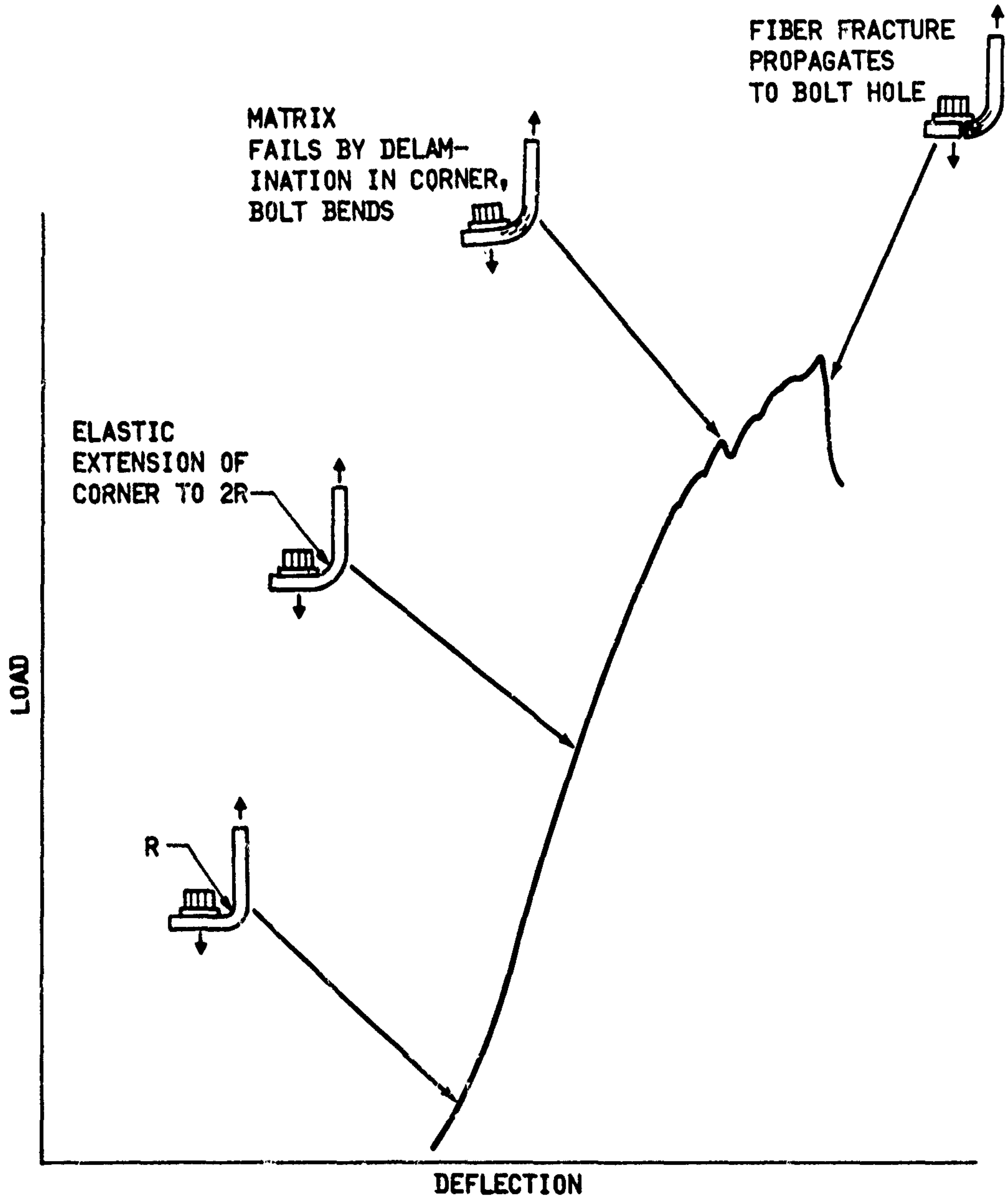


Figure B-36. Fracture Progression in Typical Composite Angle

The concept of yield strength being two-thirds of ultimate strength is not transferable from metals to composites. Permanent set may occur anywhere from 75 percent (thin angles) to 90 percent of ultimate strength (thicker angles).

Thick sections are more ductile than thin ones.

Allowable load versus thickness in composite angles is shown in Figure B-37 for an eccentricity of 0.5 inch. A similar curve for 2024-T3 aluminum has been added for comparison. With respect to angle allowables, only graphite is similar to aluminum.

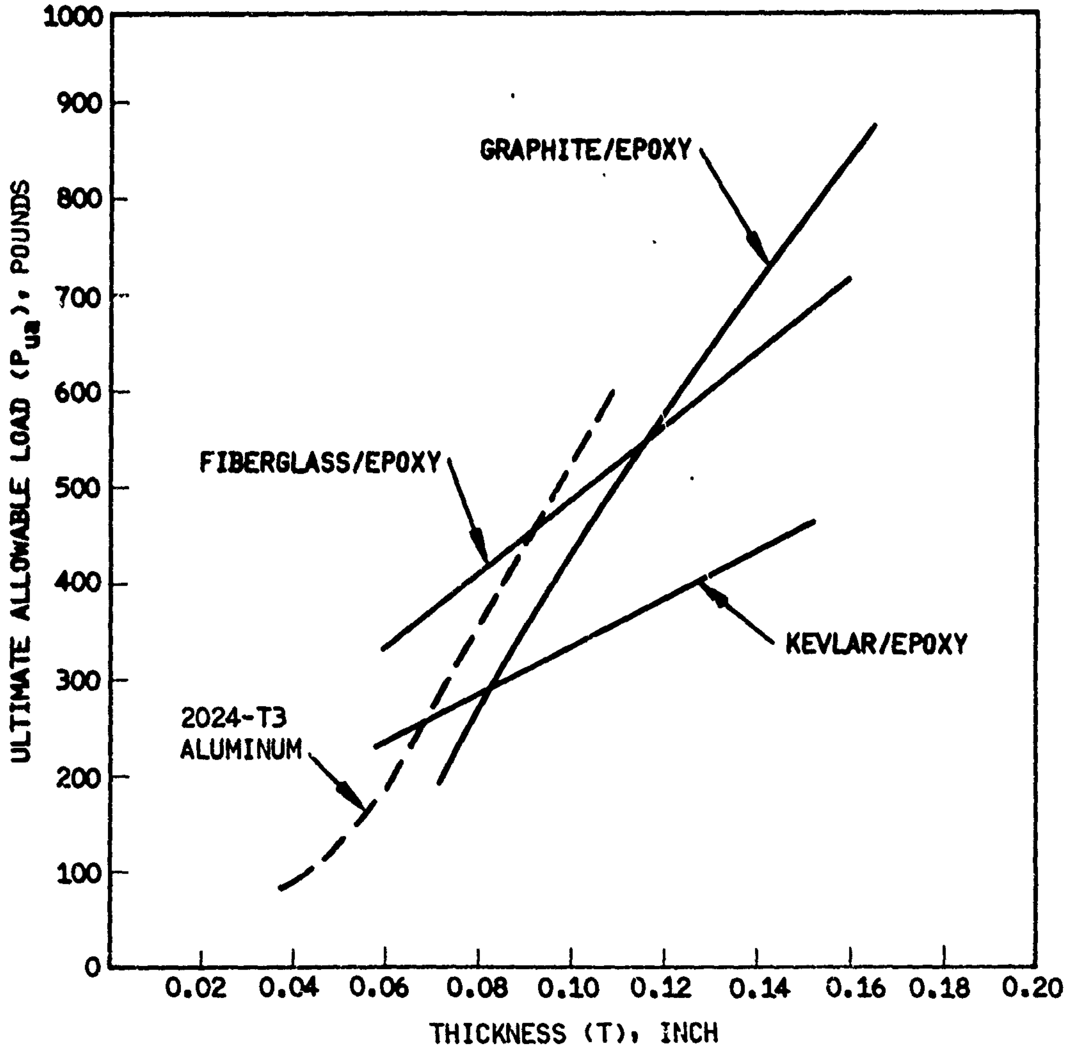


Figure B-37. Ultimate Allowable Loads Versus Thickness

APPENDIX C

C-1 MODEL PREPROCESSOR PROGRAM LISTING

```
// JOB (900004,,048),PRE91278,CLASS=B
//STEP1 EXEC FORTHCLG
      DIMENSION LAST(1000),ICUR(1000),IG(8)
      REAL*8 LEGX1,LEGY,WIDTH,RADIUS,DELTAY,DELTAX,T(26),TOLER,X,Y(26),
     *PION4,XSAVE,YSAVE,ANGLE,DIST,XLAST,YLAST,DELTAT,YY,XX,DELTY2,
     *BEND,THETA,Z(26),DELTAZ,R(26),HT2,XMOD1,XXMOD,XMOD(26),
     *YMOD(26),ZMOD,ZMOD2(26),THMOD,LEGX,LEGXP1,LEGY
      NAMELIST /PARAMS/ LEGX1,LEGY,WIDTH,RADIUS,DELTAX,DELTAY,T,
     *TOLER,DELTAT,BEND,DELTAZ,LAYERS,
     *DELTY2,HT2
      DATA IGRID/1/,JGRID/10001/,ICONT/0/,JCUR/0/,JLAST/0/,IEL/1/
      DATA LEGX1,LEGY,WIDTH,RADIUS,DELTAX,DELTAY,TOLER/7*0.0/
      DATA T/26*0.0/
      DATA DELTAT,BEND/2*0.0/,DELTAZ/0.0/,LAYERS/0/,DELTY2/0.0/
      DATA HT2/0.0/
C
C
C    THIS PROGM IS FOR GENERATING BULK DATA FOR THE FULL BRACKET
C    AND IS CALLED PRE-PROCESSOR FOR C1 MODEL
C
C     READ IN PARAMETERS
      READ(5,PARAMS)
      IF(LAYERS.EQ.0)LAYERS=1
C     ECHO PARAMETERS
      WRITE(6,8)LEGX1,LEGY,WIDTH,RADIUS,DELTAY,DELTAX,DELTAT,BEND,
     *TOLER,DELTAZ,LAYERS,DELTY2,HT2
    8 FORMAT('1PARAMETER ECHO',/,'0LEGX1= ',T13,F8.4,/,
     *' LEGY= ',T13,F8.4,/,' WIDTH= ',
     *T13,F8.4/,' RADIUS= ',T13,F8.4,/,' DELTA-Y= ',T13,F8.4,/,
     *' DELTA-X= ',T13,F8.4,/,' DELTA-T= ',T13,F8.4,/' BEND= ',T13,F8.4
     *,/,' TOLERANCE= ',F8.4,/,' DELTA-Z=',T13,
     *F8.4,/,' LAYERS=',T13,I8,/,' DELTAY2=',T13,F8.4,/,' HEIGHT2=',
     *T13,F8.4)
      DO 998 I=1,LAYERS
      WRITE(6,997) I,T(I)
997   FORMAT(' LAYER-',I2,' THICKNESS=',F8.4)
998   CONTINUE
    1 FORMAT('GRID    ',I8,8X,3F8.4)
      IF(LAYERS.GT.25)GO TO 900
C     INITIALIZE CONSTANTS
      LAYERG=LAYERS+1
      Z(1)=LEGY+BEND
      DO 35 I=2,LAYERG
      Z(I)=Z(I-1)+T(I-1)
   35 CONTINUE
      IEND2=0
      PION4=3.14159/4.
      IPSOL=1
C
C
C     GENERATE PIECE BEFORE FIRST PIECE(MODEL CHANGE 5/8/78)
C
C
C
C     START AT THE LOWER LEFTHAND CORNER
C     THEN MOVE TO THE RIGHT UNTIL WE HIT THE CUTOUT
      Y(1)=0.0
  430 X=WIDTH
```

```
C     GENERATE FAR LEFT GRID POINT
      YY=-Y(1)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 495 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
  495 CONTINUE
C     STORE GRID ID
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     INCREMENT GRID ID
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     MOVE TO THE LEFT
  490 X=X-DELTAX
C     SAVE X AND Y
      XSAVE=X
      YSAVE=Y(1)
      IF(Y(1).EQ.0.0)XX=X
C     ARE WE PAST THE 45?
      ANGLE=DATAN(Y(1)/X)
      IF(ANGLE.GT.PION4)GO TO 540
C     BELOW THE 45
C     FIND DISTANCE FROM CUTOUT
      IF(Y(1).GT.RADIUS)GO TO 550
      DIST=X-DSQRT(RADIUS**2-Y(1)**2)
C     ARE WE WITHIN TOLERANCE FROM THE CUTOUT
      IF(DIST.LE.TOLER)GO TO 480
      GO TO 550
C     ABOVE THE 45
  540 IF(X.GT.RADIUS)GO TO 550
      DIST=Y(1)-DSQRT(RADIUS**2-X**2)
      IF(DIST.LE.TOLER)GO TO 560
C     NOT AT THE CUTOUT YET SO GENERATE NORMAL GRID POINT
  550 YY=-Y(1)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 555 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
  555 CONTINUE
C     STORE GRID ID
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     IF THIS IS THE FIRST LINE OF GRIDS, DON'T GENERATE CONNECTIONS
      IF(Y(1).EQ.0.0)GO TO 490
C     MAKE SURE WE HAVE A POINT NEXT TO THIS ONE
      IF(JCUR.GT.JLAST)GO TO 560
C     GENERATE QUAD ELEMENT
```

```
C      FIRST SET UP GRID POINT ORDER
  590 IG(1)=ICUR(JCUR)
      IG(2)=ICUR(JCUR-1)
      IG(3)=LAST(JCUR-1)
      IG(4)=LAST(JCUR)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 565 J=1,LAYERS
      IF(J.EQ.1) GO TO 567
      JEL=JEL+10000
      JPSOL=JPSOL+10
      DO 566 K=1,8
      IG(K)=IG(K)+10000
  566 CONTINUE
C      PUNCH CONNECTION CARD
  567 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
C      INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C      PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
  565 CONTINUE
C      INCREMENT ELEMENT ID
      IEL=IEL+1
C      KEEP GOING TILL WE HIT THE CUTOUT
      GO TO 490
C      IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
  580 YY=-DSQRT(RADIUS**2-X**2)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 585 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
  585 CONTINUE
C      STORE GRID ID
      JLAST=JLAST+1
      LAST(JLAST)=IGRID
C      INCREMENT GRID ID
      IGRID=IGRID+1
      JGRID=IGRID+10000
      GO TO 590
C
C      WE'VE HIT THE CUTOUT, SO GENERATE
C      A GRID POINT ON THE CURVE OF THE CUTOUT
C      WE'RE ABOVE THE 45, SO MOVE IN THE Y-DIRECTION
  560 Y(1)=DSQRT(RADIUS**2-X**2)
      GO TO 570
C      WE'RE BELOW THE 45 SO MOVE IN THE X-DIRECTION
  480 X=DSQRT(RADIUS**2-Y(1)**2)
  570 YY=-Y(1)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
```

```
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 575 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
  575 CONTINUE
C     STORE GRID ID
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     IF THIS IS THE FIRST LINE OF GRIDS, DON'T GENERATE CONNECTIONS
      IF(Y(1).EQ.0.0)GO TO 530
C     DID WE CROSS A LINE OF GRIDS?
      IF(XSAVE.NE.XLAST)GO TO 500
C     WE DIDN'T CROSS A LINE OF GRIDS SO
C     GENERATE A QUAD ELEMENT
C     FIRST SET UP THE GRID ORDER
      IG(1)=ICUR(JCUR)
      IG(2)=ICUR(JCUR-1)
      IG(3)=LAST(JCUR-1)
      IG(4)=LAST(JCUR)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 576 J=1,LAYERS
      IF(J.EQ.1)GO TO 578
      JPSOL=JPSOL+10
      JEL=JEL+10000
      DO 577 K=1,8
      IG(K)=IG(K)+10000
  577 CONTINUE
C     PUNCH CONNECTION CARD
  578 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
C     INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
  576 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
      GO TO 530
C
C     WE CROSSED A LINE OF GRIDS SO WE NEED A TRIANGULAR
C     ELEMENT INSTEAD OF A QUAD ELEMENT
C     FIRST SET UP THE GRID ORDER
  500 IG(1)=ICUR(JCUR-1)
      IG(2)=LAST(JCUR-1)
      IG(3)=ICUR(JCUR)
      IG(4)=IG(1)+10000
      IG(5)=IG(2)+10000
      IG(6)=IG(3)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 505 J=1,LAYERS
```

```
      IF(J.EQ.1) GO TO 507
      JPSOL=JPSOL+10
      JEL=JEL+10000
      DO 506 K=1,6
      IG(K)=IG(K)+10000
  506 CONTINUE
C     PUNCH CONNECTION CARD
  507 WRITE(7,4)JEL,JPSOL,(IG(I),I=1,6)
    4 FORMAT('CPENTA  ',8I8)
  505 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
C     SAVE LAST X AND Y VALUES
  530 YLAST=YSAVE
      XLAST=XSAVE
C     NOW MOVE CURRENT GRIDS TO LAST GRIDS
      DO 510 I=1,JCUR
      LAST(I)=ICUR(I)
  510 CONTINUE
      JLAST=JCUR
C     RESET CURRENT GRID COUNTER
      JCUR=0
C     MOVE UP A LINE
      IF(ANGLE.GT.PION4)Y(1)=YSAVE
      Y(1)=Y(1)+DELTY2
C     ARE WE AT THE TOP OF THE CUTOUT?
      IF(Y(1).LT.(RADIUS+TOLER))GO TO 430
C     START GOING UP IN THE Y-DIRECTION UNTIL WE HIT THE TOP
C     START AT THE LEFT EDGE
      Y(1)=Y(1)-DELTY2
      GO TO 475
  420 X=WIDTH
C     GENERATE NEXT LINE OF GRID POINTS
      IEND=0
  440 YY=-Y(1)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 445 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
  445 CONTINUE
C     SAVE GRID ID'S FOR ELEMENT CONNECTIONS
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     SEE IF THERE IS A POINT NEXT TO THIS ONE
      IF (JCUR.GT.JLAST)GO TO 452
C     MOVE TO THE RIGHT ONE INCREMENT AND REPEAT
  451 X=X-DELTAX
      IF(X.GT.TOLER)GO TO 440
C     MAKE SURE WE GET THE RIGHT EDGE
      IF(IEND.EQ.1)GO TO 450
      X=0.0
      IEND=1
      GO TO 440
```

```
C
C     GENERATE ELEMENT CONNECTIONS
C
  450 DO 460 I=2,JLAST
C     FIRST SET UP THE GRID POINT ORDER
      IG(1)=ICUR(I)
      IG(2)=ICUR(I-1)
      IG(3)=LAST(I-1)
      IG(4)=LAST(I)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 455 K=1,LAYERS
      IF(K.EQ.1) GO TO 457
      JEL=JEL+10000
      JPSOL=JPSOL+10
      DO 456 L=1,8
      IG(L)=IG(L)+10000
  456 CONTINUE
C     PUNCH CONNECTION CARD
  457 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
C     INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
    2 FORMAT('CHEXA    ',8I8,'+',I7)
    3 FORMAT('+',I7,2I8)
  455 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
  460 CONTINUE
C     MOVE CURRENT LINE OF GRIDS TO LAST LINE
      DO 470 I=1,JCUR
      LAST(I)=ICUR(I)
  470 CONTINUE
      JLAST=JCUR
C     MAKE CURRENT LINE EMPTY
      JCUR=0
C     MOVE UP A LINE
  475 Y(1)=Y(1)+DELTY2
C     HAVE WE HIT THE TOP YET?
      IF(Y(1).LT.(HT2-TOLER))GO TO 420
      IF(IEND2.EQ.1)GO TO 600
      IEND2=1
      Y(1)=HT2
      GO TO 420
C     IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
  452 YY=-DSQRT(RADIUS**2-X**2)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 453 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
```

```
  453 CONTINUE
C     STORE GRID ID
      JLAST=JLAST+1
      LAST(JLAST)=IGRID
C     INCREMENT GRID ID
      IGRID=IGRID+1
      JGRID=IGRID+10000
      GO TO 451
  600 IGRID=(IGRID/1000+1)*1000+1
      JGRID=IGRID+10000
      IEL=(IEL/1000+1)*1000+1
      XLAST=XX
      IEND2=0
C
C
C     GENERATE FIRST PIECE WITH CUTOUT IN IT
C
C
C
C     START AT THE LOWER LEFTHAND CORNER
C     THEN MOVE TO THE RIGHT UNTIL WE HIT THE CUTOUT
      Y(1)=DELTAY
   30 X=WIDTH
C     GENERATE FAR LEFT GRID POINT
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XMOD(1)=Y(1)+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
      DO 95 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
      JGRID=JGRID+10000
   95 CONTINUE
C     STORE GRID ID
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     IF FIRST LINE OF GRIDS PICK UP GRID # FOR LAST LINE
      IF(Y(1).EQ.DELTAY)LAST(JCUR)=MOD(IGRID,1000)
      IF(Y(1).EQ.DELTAY)JLAST=JCUR
C     INCREMENT GRID ID
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     MOVE TO THE LEFT
   90 X=X-DELTAX
C     SAVE X AND Y
      XSAVE=X
      YSAVE=Y(1)
C     ARE WE PAST THE 45?
      ANGLE=DATAN(Y(1)/X)
      IF(ANGLE.GT.PION4)GO TO 140
C     BELOW THE 45
C     FIND DISTANCE FROM CUTOUT
      IF(Y(1).GT.RADIUS)GO TO 150
      DIST=X-DSQRT(RADIUS**2-Y(1)**2)
C     ARE WE WITHIN TOLERANCE FROM THE CUTOUT
      IF(DIST.LE.TOLER)GO TO 80
      GO TO 150
C     ABOVE THE 45
  140 IF(X.GT.RADIUS)GO TO 150
      DIST=Y(1)-DSQRT(RADIUS**2-X**2)
```

```
      IF(DIST.LE.TOLER)GO TO 160
C     NOT AT THE CUTOUT YET SO GENERATE NORMAL GRID POINT
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
  150 XMOD(1)=Y(1)+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
      DO 155 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
      JGRID=JGRID+10000
  155 CONTINUE
C     STORE GRID ID
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     IF FIRST LINE OF GRIDS, PICK UP GRID # FOR LAST LINE
      IF(Y(1).EQ.DELTAY)LAST(JCUR)=MOD(IGRID,1000)
      IF(Y(1).EQ.DELTAY)JLAST=JCUR
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     MAKE SURE WE HAVE A POINT NEXT TO THIS ONE
      IF(JCUR.GT.JLAST)GO TO 180
C     GENERATE QUAD ELEMENT
C     FIRST SET UP GRID POINT ORDER
  190 IG(1)=LAST(JCUR)
      IG(2)=LAST(JCUR-1)
      IG(3)=ICUR(JCUR-1)
      IG(4)=ICUR(JCUR)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 165 J=1,LAYERS
      IF(J.EQ.1) GO TO 167
      JEL=JEL+10000
      JPSOL=JPSOL+10
      DO 166 K=1,8
      IG(K)=IG(K)+10000
  166 CONTINUE
C     PUNCH CONNECTION CARD
  167 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
C     INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
  165 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
C     KEEP GOING TILL WE HIT THE CUTOUT
      GO TO 90
C     IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
  180 YY=+DSQRT(RADIUS**2-X**2)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
```

```
      DO 185 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
  185 CONTINUE
C     STORE GRID ID
      JLAST=JLAST+1
      LAST(JLAST)=IGRID
C     INCREMENT GRID ID
      IGRID=IGRID+1
      JGRID=IGRID+10000
      GO TO 190
C
C     WE'VE HIT THE CUTOUT, SO GENERATE
C     A GRID POINT ON THE CURVE OF THE CUTOUT
C     WE'RE ABOVE THE 45, SO MOVE IN THE Y-DIRECTION
  160 Y(1)=DSQRT(RADIUS**2-X**2)
      GO TO 170
C     WE'RE BELOW THE 45 SO MOVE IN THE X-DIRECTION
   80 X=DSQRT(RADIUS**2-Y(1)**2)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
  170 XMOD(1)=Y(1)+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
      DO 175 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
      JGRID=JGRID+10000
  175 CONTINUE
C     STORE GRID ID
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     IF FIRST LINE OF GRIDS, PICK UP GRID # FOR LAST LINE
      IF(Y(1).EQ.DELTAY)LAST(JCUR)=MOD(IGRID,1000)
      IF(Y(1).EQ.DELTAY)JLAST=JCUR
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     DID WE CROSS A LINE OF GRIDS?
      IF(XSAVE.NE.XLAST)GO TO 100
C     WE DIDN'T CROSS A LINE OF GRIDS SO
C     GENERATE A QUAD ELEMENT
C     FIRST SET UP THE GRID ORDER
      IG(1)=LAST(JCUR)
      IG(2)=LAST(JCUR-1)
      IG(3)=ICUR(JCUR-1)
      IG(4)=ICUR(JCUR)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 176 J=1,LAYERS
      IF(J.EQ.1)GO TO 178
      JPSOL=JPSOL+10
      JEL=JEL+10000
      DO 177 K=1,8
      IG(K)=IG(K)+10000
  177 CONTINUE
```

```
C     PUNCH CONNECTION CARD
  178 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
C     INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
  176 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
      GO TO 130
C
C     WE CROSSED A LINE OF GRIDS SO WE NEED A TRIANGULAR
C     ELEMENT INSTEAD OF A QUAD ELEMENT
C     FIRST SET UP THE GRID ORDER
  100 IG(1)=LAST(JCUR-1)
      IG(2)=ICUR(JCUR-1)
      IG(3)=ICUR(JCUR)
      IG(4)=IG(1)+10000
      IG(5)=IG(2)+10000
      IG(6)=IG(3)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 105 J=1,LAYERS
      IF(J.EQ.1) GO TO 107
      JPSOL=JPSOL+10
      JEL=JEL+10000
      DO 106 K=1,6
      IG(K)=IG(K)+10000
  106 CONTINUE
C     PUNCH CONNECTION CARD
  107 WRITE(7,4)JEL,JPSOL,(IG(I),I=1,6)
  105 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
C     SAVE LAST X AND Y VALUES
  130 YLAST=YSAVE
      XLAST=XSAVE
C     NOW MOVE CURRENT GRIDS TO LAST GRIDS
      DO 110 I=1,JCUR
      LAST(I)=ICUR(I)
  110 CONTINUE
      JLAST=JCUR
C     RESET CURRENT GRID COUNTER
      JCUR=0
C     MOVE UP A LINE
      IF(ANGLE.GT.PION4)Y(1)=YSAVE
      Y(1)=Y(1)+DELTAY
C     ARE WE AT THE TOP OF THE CUTOUT?
      IF(Y(1).LT.(RADIUS+TOLER))GO TO 30
C     START GOING UP IN THE Y-DIRECTION UNTIL WE HIT THE TOP
C     START AT THE LEFT EDGE
      Y(1)=Y(1)-DELTAY
      GO TO 75
   20 X=WIDTH
C     GENERATE NEXT LINE OF GRID POINTS
      IEND=0
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
   40 XMOD(1)=Y(1)+HT2
      YMOD(1)=Z(1)
      ZMOD=X
```

```
      WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
      DO  45 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
      JGRID=JGRID+10000
   45 CONTINUE
C     SAVE GRID ID'S FOR ELEMENT CONNECTIONS
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     SEE IF THERE IS A POINT NEXT TO THIS ONE
      IF (JCUR.GT.JLAST)GO TO 52
C     MOVE TO THE RIGHT ONE INCREMENT AND REPEAT
   51 X=X-DELTAX
      IF(X.GT.TOLER)GO TO 40
C     MAKE SURE WE GET THE RIGHT EDGE
      IF(IEND.EQ.1)GO TO 50
      X=0.0
      IEND=1
      GO TO 40
C
C     GENERATE ELEMENT CONNECTIONS
C
   50 DO 60 I=2,JLAST
C     FIRST SET UP THE GRID POINT ORDER
      IG(1)=LAST(I)
      IG(2)=LAST(I-1)
      IG(3)=ICUR(I-1)
      IG(4)=ICUR(I)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 55 K=1,LAYERS
      IF(K.EQ.1) GO TO 57
      JEL=JEL+10000
      JPSOL=JPSOL+10
      DO 56 L=1,8
      IG(L)=IG(L)+10000
   56 CONTINUE
C     PUNCH CONNECTION CARD
   57 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
C     INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
   55 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
   60 CONTINUE
C     MOVE CURRENT LINE OF GRIDS TO LAST LINE
      DO 70 I=1,JCUR
      LAST(I)=ICUR(I)
   70 CONTINUE
      JLAST=JCUR
C     MAKE CURRENT LINE EMPTY
```

```
      JCUR=0
C     MOVE UP A LINE
   75 Y(1)=Y(1)+DELTAY
C     HAVE WE HIT THE TOP YET?
      IF(Y(1).LT.(LEGX1-TOLER))GO TO 20
      IF(IEND2.EQ.1)GO TO 200
      IEND2=1
      Y(1)=LEGX1
      GO TO 20
C     IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
   52 YY=+DSQRT(RADIUS**2-X**2)
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
      XXMOD=YY+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
      DO 53 I=2,LAYERG
      YMOD(I)=Z(I)
      WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
      JGRID=JGRID+10000
   53 CONTINUE
C     STORE GRID ID
      JLAST=JLAST+1
      LAST(JLAST)=IGRID
C     INCREMENT GRID ID
      IGRID=IGRID+1
      JGRID=IGRID+10000
      GO TO 51
C
C
C     END OF FIRST PIECE
C
C
C
C     GENERATE THE 90-DEGREE BEND
C
C     FIRST ESTABLISH A CYLINDRICAL CO-ORDINATE SYSTEM
  200 X=0.0
      LEGX=HT2+LEGX1
      LEGXP1=LEGX+1.
      LEGY=LEGY
      WRITE(7,201)LEGX,LEGY,LEGX,LEGY,ICONT
  201 FORMAT('CORD2C  ',5X,'100',8X,2F8.4,5X,'0.0',2F8.4,5X,'1.0+',
     *I7)
      JCONT=ICONT
      ICONT=ICONT+1
      WRITE(7,202)JCONT,LEGXP1,LEGY
  202 FORMAT('+',I7,2F8.4,5X,'0.0')
C     SET INITIAL VALUES
      IPSOL=IPSOL+1
      R(1)=BEND
      DO 205 I=2,LAYERG
      R(I)=R(I-1)+T(I-1)
  205 CONTINUE
      THETA=DELTAT
      IEL=((IEL/1000)+1)*1000+1
      IEND2=0
  250 IEND=0
      Z(1)=0.0
C    TRANSFORMING FROM ORIGINAL TO MODIFIED CYLINDRICAL COORD SYSTEM
  220 THMOD=90.-THETA
```

```
      ZMOD2(1)=WIDTH-Z(1)
      WRITE(7,203)IGRID,R(1),THMOD,ZMOD2(1)
  203 FORMAT('GRID    ',I8,5X,'100',3F8.4)
      DO 225 I=2,LAYERG
      WRITE(7,203)JGRID,R(I),THMOD,ZMOD2(1)
      JGRID=JGRID+10000
  225 CONTINUE
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
      IGRID=IGRID+1
      JGRID=IGRID+10000
      Z(1)=Z(1)+DELTAX
      IF(Z(1).LT.(WIDTH-TOLER))GO TO 220
C     MAKE SURE WE GET THE EDGE
      IF(IEND.EQ.1)GO TO 210
      Z(1)=WIDTH
      IEND=1
      GO TO 220
C     GENERATE CONNECTIONS
  210 DO 230 I=2,JCUR
C     SET UP THE GRID POINT ORDER
      IG(1)=LAST(I)
      IG(2)=LAST(I-1)
      IG(3)=ICUR(I-1)
      IG(4)=ICUR(I)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
      JPSOL=IPSOL
      DO 215 K=1,LAYERS
      IF(K.EQ.1)GO TO 217
      JEL=JEL+10000
      JPSOL=JPSOL+10
      DO 216 L=1,8
      IG(L)=IG(L)+10000
  216 CONTINUE
C     PUNCH CONNECTION CARD
  217 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
C     INCREMENT CONTINUATION
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
  215 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
  230 CONTINUE
C     MOVE CURRENT GRIDS TO LAST GRIDS
      DO 240 I=1,JCUR
      LAST(I)=ICUR(I)
  240 CONTINUE
      JLAST=JCUR
      JCUR=0
C     INCREMENT ANGLE
      THETA=THETA+DELTAT
      IF(THETA.LT.89.99995)GO TO 250
      IF(IEND2.EQ.1)GO TO 241
      IEND2=1
      THETA=90.
```

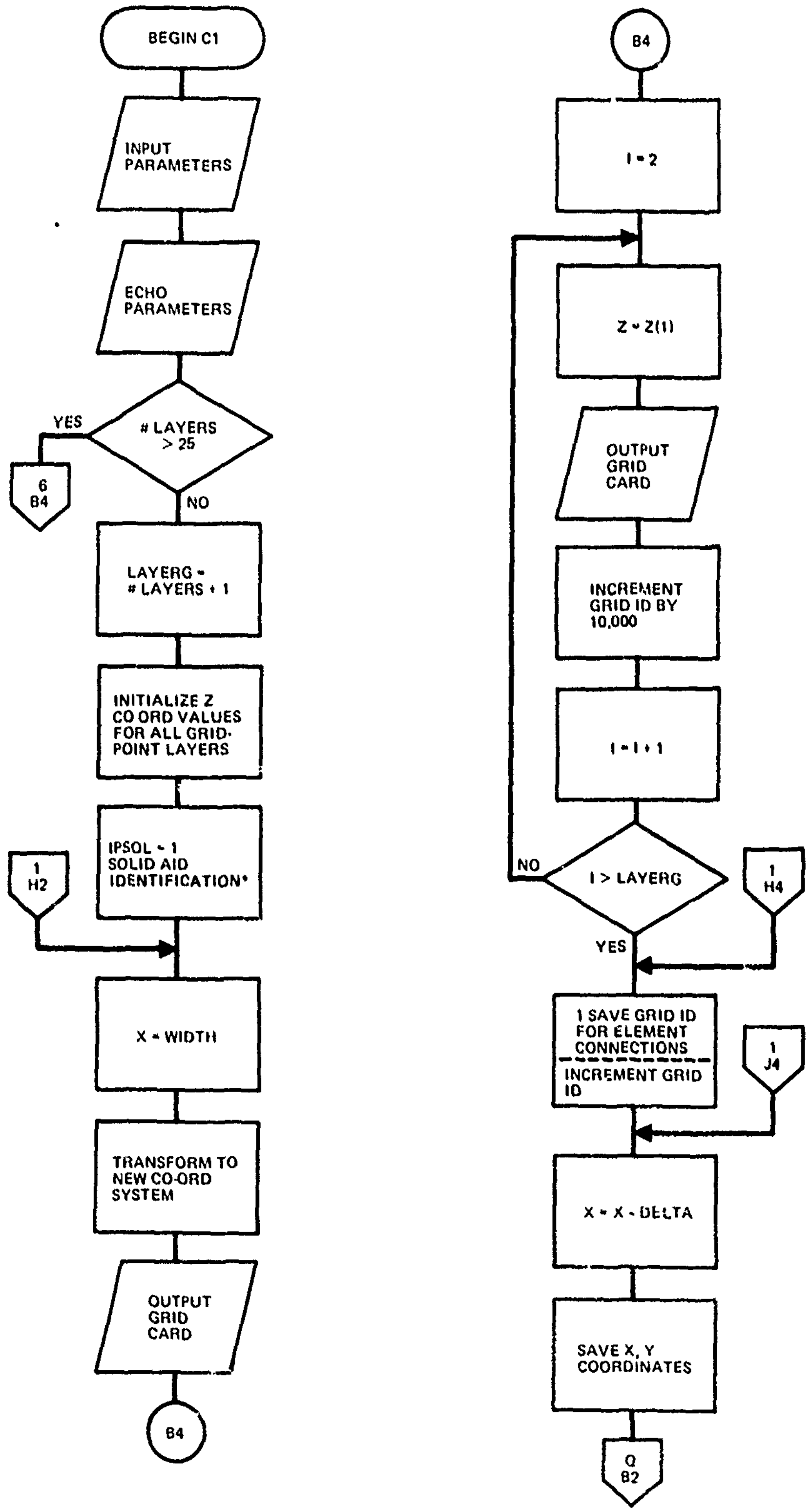
```
      GO TO 250
C
C     END OF 90 DEGREE BEND
C
C
C
C     START OF BOTTOM PIECE(NO CUTOUT)
C
C
C     INITIALIZE CONSTANTS
  241 IEL=((IEL/1000)+1)*1000+1
      IEND2=0
      IPSOL=IPSOL+1
      Y(1)=LEGX1+BEND
      DO 245 I=2,LAYERG
      Y(I)=Y(I-1)+T(I-1)
  245 CONTINUE
C     START GOING DOWN IN THE Z-DIRECTION UNTIL WE HIT THE BOTTOM
C     START AT THE LEFT EDGE
      Z(1)=LEGY-DELTAZ
  320 X=WIDTH
C     GENERATE NEXT LINE OF GRID POINTS
      IEND=0
C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
  340 XMOD(1)=Y(1)+HT2
      YMOD(1)=Z(1)
      ZMOD=X
      WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
      DO 345 I=2,LAYERG
      XMOD(I)=Y(I)+HT2
      WRITE(7,1)JGRID,XMOD(I),YMOD(1),ZMOD
      JGRID=JGRID+10000
  345 CONTINUE
C     SAVE GRID ID'S FOR ELEMENT CONNECTIONS
      JCUR=JCUR+1
      ICUR(JCUR)=IGRID
C     INCREMENT GRID ID'S
      IGRID=IGRID+1
      JGRID=IGRID+10000
C     MOVE TO THE RIGHT ONE INCREMENT AND REPEAT
      X=X-DELTAX
      IF(X.GT.TOLER)GO TO 340
C     MAKE SURE WE GET THE RIGHT EDGE
      IF(IEND.EQ.1)GO TO 350
      X=0.0
      IEND=1
      GO TO 340
C
C     GENERATE ELEMENT CONNECTIONS
C
  350 DO 360 I=2,JLAST
C     FIRST SET UP THE GRID POINT ORDER
      IG(1)=LAST(I)
      IG(2)=LAST(I-1)
      IG(3)=ICUR(I-1)
      IG(4)=ICUR(I)
      IG(5)=IG(1)+10000
      IG(6)=IG(2)+10000
      IG(7)=IG(3)+10000
      IG(8)=IG(4)+10000
      JEL=IEL
```

```
      JPSOL=IPSOL
      DO 355 K=1,LAYERS
      IF(K.EQ.1)GO TO 357
      JEL=JEL+10000
      JPSOL=JPSOL+10
      DO 356 L=1,8
      IG(L)=IG(L)+10000
  356 CONTINUE
C     PUNCH CONNECTION CARD
  357 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
C     INCREMENT CONTINUATION FIELD
      JCONT=ICONT
      ICONT=ICONT+1
C     PUNCH CONTINUATION OF CONNECTION CARD
      WRITE(7,3)JCONT,IG(7),IG(8)
  355 CONTINUE
C     INCREMENT ELEMENT ID
      IEL=IEL+1
  360 CONTINUE
C     MOVE CURRENT LINE OF GRIDS TO LAST LINE
      DO 370 I=1,JCUR
      LAST(I)=ICUR(I)
  370 CONTINUE
      JLAST=JCUR
C     MAKE CURRENT LINE EMPTY
      JCUR=0
C     MOVE UP A LINE
      Z(1)=Z(1)-DELTAZ
C     HAVE WE HIT THE BOTTOM YET?
      IF(Z(1).GT.TOLER)GO TO 320
      IF(IEND2.EQ.1)GO TO 120
      IEND2=1
      Z(1)=0.0
      GO TO 320
C     WERE DONE    WHEW
C     SO DUMP THE BUFFER
  120 ENDFILE 7
C     AND GET THE HELL OUT
      STOP
  900 WRITE(6,901)
  901 FORMAT('-***ERROR***  TOO MANY LAYERS SPECIFIED')
      STOP
      END
//GO.FT07F001 DD DSN=CN900004.SSS.C18BLKXF,UNIT=WYLBUR,DISP=(,CATLG),
//   SPACE=(TRK,(10,10),RLSE),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)     JCL
//GO.SYSIN DD *
 &PARAMS   LEGX1=0.27,LEGY=0.51,WIDTH=0.5,RADIUS=0.25,DELTAY=0.05,
   DELTAX=0.1,TOLER=0.015,DELTAT=15.0,BEND=0.125,
   T(1)=0.125,                                                      INPUT DATA
   DELTAZ=0.17,LAYERS=1,DELTY2=0.1330,HT2=0.4
 &END
```

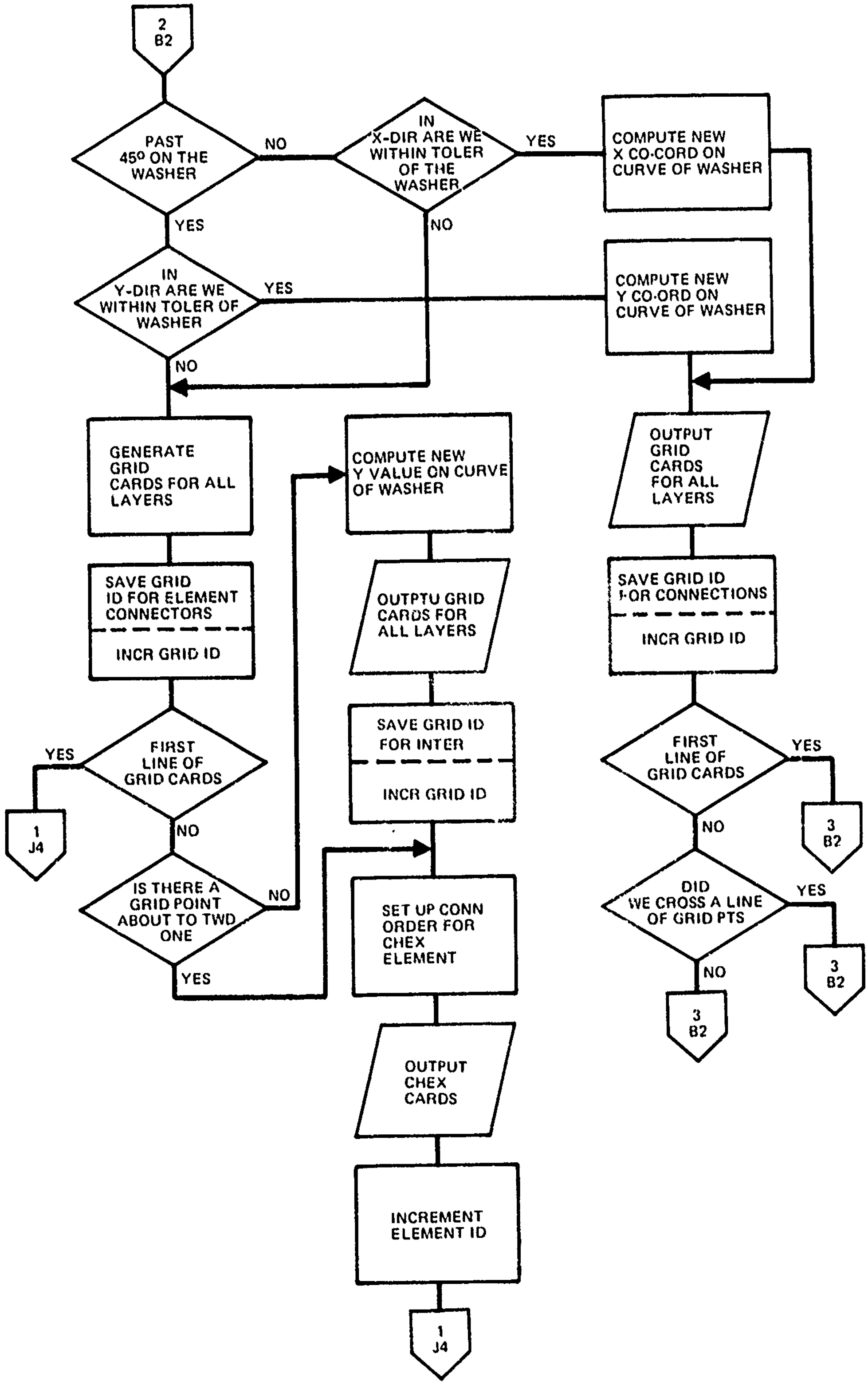
(ALSO SEE FIGURE B-13)

APPENDIX D

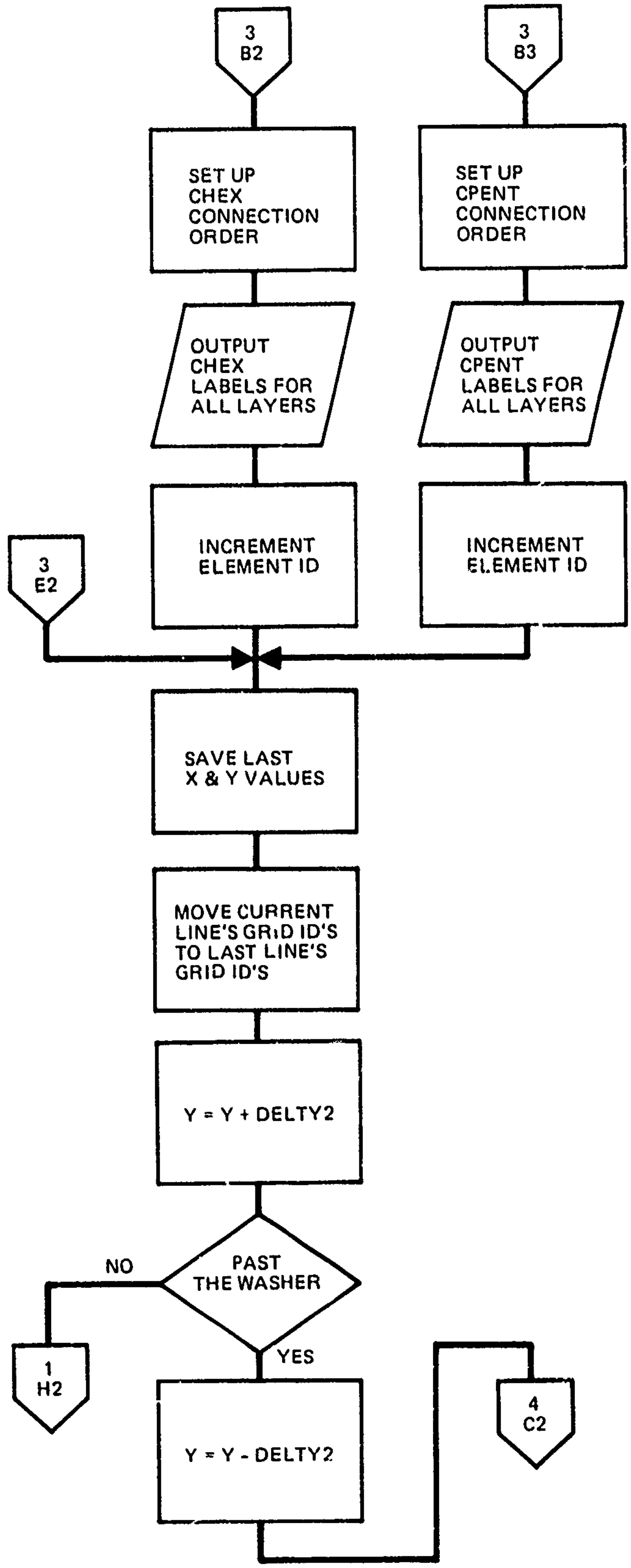
C-1 PREPROCESSOR FLOWCHART



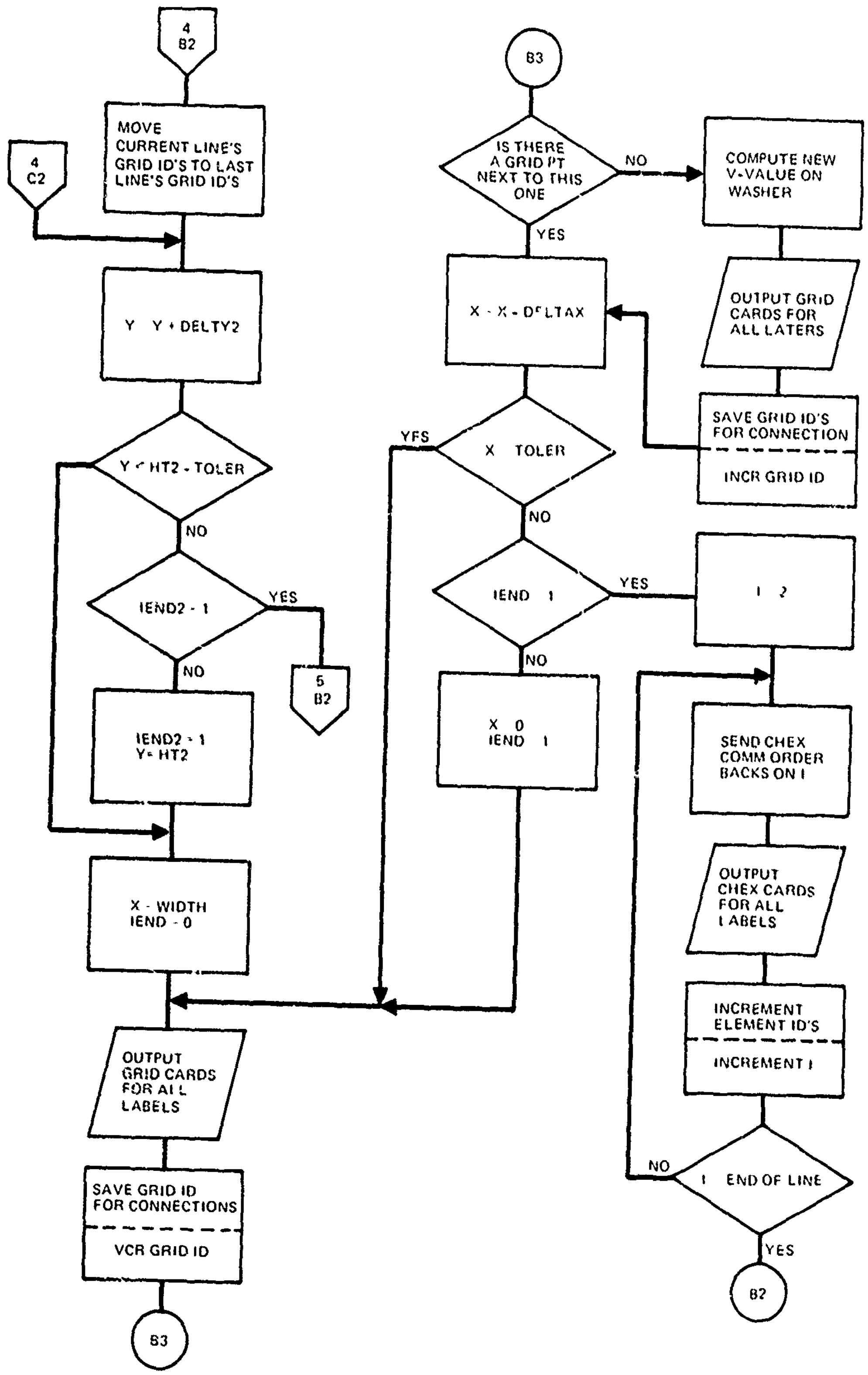
C-1 PREPROCESSOR



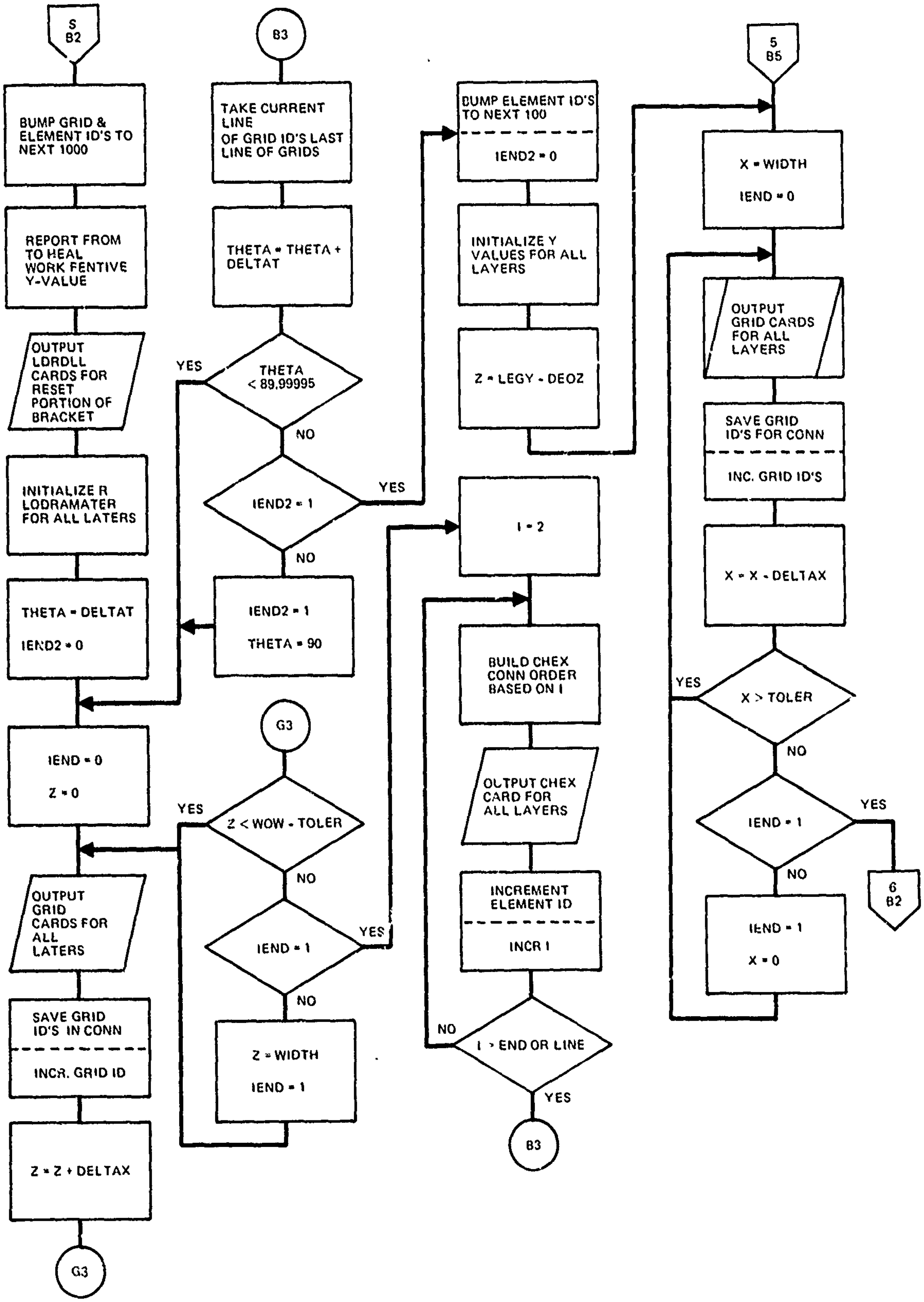
C-1 PREPROCESSOR



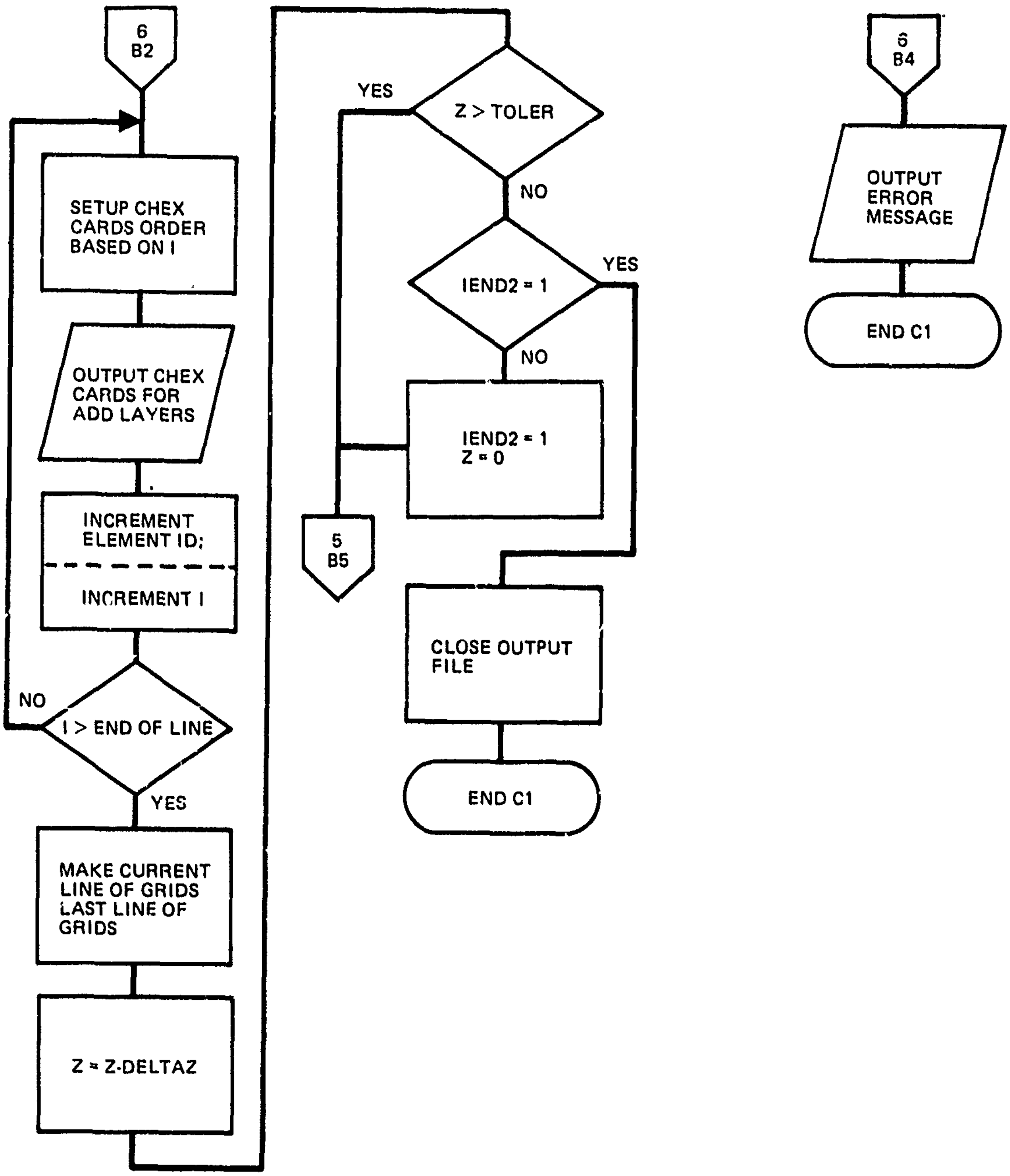
C-1 PREPROCESSOR



C-1 PREPROCESSOR



C-1 PREPROCESSOR



APPENDIX E

C-1 MODEL PREPROCESSOR PROGRAM OUTPUT

```
LEVEL 21.8 ( JUN 74 )                         OS/360  FORTRAN H

     COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=56,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,XREF
ISN 0002            DIMENSION LAST(1000),ICUR(1000),IG(8)
ISN 0003            REAL*8 LEGX1,LEGY,WIDTH,RADIUS,DELTAY,DELTAX,T(26),TOLER,X,Y(26)
                   *PION4,XSAVE,YSAVE,ANGLE,DIST,XLAST,YLAST,DELTAT,YY,XX,DELTY2,
                   *BEND,THETA,Z(26),DELTAZ,R(26),HT2,XMOD1,XXMOD,XMOD(26),
                   *YMOD(26),ZMOD,ZMOD2(26),THMOD,LEGX,LEGXP1,LEGY
ISN 0004            NAMELIST /PARAMS/ LEGX1,LEGY,WIDTH,RADIUS,DELTAX,DELTAY,T,
                   *TOLER,DELTAT,BEND,DELTAZ,LAYERS,
                   *DELTY2,HT2
ISN 0005            DATA IGRID/1/,JGRID/10001/,ICONT/0/,JCUR/0/,JLAST/0/,IEL/1/
ISN 0006            DATA LEGX1,LEGY,WIDTH,RADIUS,DELTAX,DELTAY,TOLER/7*0.0/
ISN 0007            DATA T/26*0.0/
ISN 0008            DATA DELTAT,BEND/2*0.0/,DELTAZ/0.0/,LAYERS/0/,DELTY2/0.0/
ISN 0009            DATA HT2/0.0/
              C
              C
              C   THIS PROGM IS FOR GENERATING BULK DATA FOR THE FULL BRACKET
              C   AND IS CALLED PRE-PROCESSOR FOR C1 MODEL
              C
              C     READ IN PARAMETERS
ISN 0010            READ(5,PARAMS)
ISN 0011            IF(LAYERS.EQ.0)LAYERS=1
              C     ECHO PARAMETERS
ISN 0013            WRITE(6,8)LEGX1,LEGY,WIDTH,RADIUS,DELTAY,DELTAX,DELTAT,BEND,
                   *TOLER,DELTAZ,LAYERS,DELTY2,HT2
ISN 0014          8 FORMAT('1PARAMETER ECHO',/,'OLEGX1= ',T13,F8.4,/,
                   *' LEGY= ',T13,F8.4,/,' WIDTH= ',
                   *T13,F8.4/,' RADIUS= ',T13,F8.4,/,' DELTA-Y= ',T13,F6.4,/,
                   *' DELTA-X= ',T13,F8.4,/,' DELTA-T= ',T13,F8.4,/' BEND= ',T13,F8.
                   *,/,' TOLERANCE= ',F8.4,/,' DELTA-Z=',T13,
                   *F8.4,/,' LAYERS=',T13,I8,/,' DELTAY2=',T13,F8.4,/,' HEIGHT2=',
                   *T13,F8.4)
ISN 0015            DO 998 I=1,LAYERS
ISN 0016            WRITE(6,997) I,T(I)
ISN 0017      997   FORMAT(' LAYER-',I2,' THICKNESS=',F8.4)
ISN 0018      998   CONTINUE
ISN 0019          1 FORMAT('GRID    ',I8,8X,3F8.4)
ISN 0020            IF(LAYERS.GT.25)GO TO 900
              C     INITIALIZE CONSTANTS
ISN 0022            LAYERG=LAYERS+1
ISN 0023            Z(1)=LEGY+BEND
ISN 0024            DO 35 I=2,LAYERG
ISN 0025            Z(I)=Z(I-1)+T(I-1)
ISN 0026         35 CONTINUE
ISN 0027            IEND2=0
ISN 0028            PION4=3.14159/4.
ISN 0029            IPSOL=1
              C
              C
              C     GENERATE PIECE BEFORE FIRST PIECE(MODEL CHANGE 5/6/78)
              C
              C
              C
```

```
               C      START AT THE LOWER LEFTHAND CORNER
               C      THEN MOVE TO THE RIGHT UNTIL WE HIT THE CUTOUT
ISN 0030              Y(1)=0.0
ISN 0031          430 X=WIDTH
               C      GENERATE FAR LEFT GRID POINT
ISN 0032              YY=-Y(1)
               C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0033              XXMOD=YY+HT2
ISN 0034              YMOD(1)=Z(1)
ISN 0035              ZMOD=X
ISN 0036              WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0037              DO 495 I=2,LAYERG
ISN 0038              YMOD(I)=Z(I)
ISN 0039              WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0040              JGRID=JGRID+10000
ISN 0041          495 CONTINUE
               C      STORE GRID ID
ISN 0042              JCUR=JCUR+1
ISN 0043              ICUR(JCUR)=IGRID
               C      INCREMENT GRID ID
ISN 0044              IGRID=IGRID+1
ISN 0045              JGRID=IGRID+10000
               C      MOVE TO THE LEFT
ISN 0046          490 X=X-DELTAX
               C      SAVE X AND Y
ISN 0047              XSAVE=X
ISN 0048              YSAVE=Y(1)
ISN 0049              IF(Y(1).EQ.0.0)XX=X
               C      ARE WE PAST THE 45?
ISN 0051              ANGLE=DATAN(Y(1)/X)
ISN 0052              IF(ANGLE.GT.PION4)GO TO 540
               C      BELOW THE 45
               C      FIND DISTANCE FROM CUTOUT
ISN 0054              IF(Y(1).GT.RADIUS)GO TO 550
ISN 0056              DIST=X-DSQRT(RADIUS**2-Y(1)**2)
               C      ARE WE WITHIN TOLERANCE FROM THE CUTOUT
ISN 0057              IF(DIST.LE.TOLER)GO TO 480
ISN 0059              GO TO 550
               C      ABOVE THE 45
ISN 0060          540 IF(X.GT.RADIUS)GO TO 550
ISN 0062              DIST=Y(1)-DSQRT(RADIUS**2-X**2)
ISN 0063              IF(DIST.LE.TOLER)GO TO 560
               C      NOT AT THE CUTOUT YET SO GENERATE NORMAL GRID POINT
ISN 0065          550 YY=-Y(1)
               C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0066              XXMOD=YY+HT2
ISN 0067              YMOD(1)=Z(1)
ISN 0068              ZMOD=X
ISN 0069              WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0070              DO 555 I=2,LAYERG
ISN 0071              YMOD(I)=Z(I)
ISN 0072              WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0073              JGRID=JGRID+10000
ISN 0074          555 CONTINUE
```

```
              C     STORE GRID ID
ISN 0075            JCUR=JCUR+1
ISN 0076            ICUR(JCUR)=IGRID
              C     INCREMENT GRID ID'S
ISN 0077            IGRID=IGRID+1
ISN 0078            JGRID=IGRID+10000
              C     IF THIS IS THE FIRST LINE OF GRIDS, DON'T GENERATE CONNECTIONS
ISN 0079            IF(Y(1).EQ.0.0)GO TO 490
              C     MAKE SURE WE HAVE A POINT NEXT TO THIS ONE
ISN 0081            IF(JCUR.GT.JLAST)GO TO 580
              C     GENERATE QUAD ELEMENT
              C     FIRST SET UP GRID POINT ORDER
ISN 0083        590 IG(1)=ICUR(JCUR)
ISN 0084            IG(2)=ICUR(JCUR-1)
ISN 0085            IG(3)=LAST(JCUR-1)
ISN 0086            IG(4)=LAST(JCUR)
ISN 0087            IG(5)=IG(1)+10000
ISN 0088            IG(6)=IG(2)+10000
ISN 0089            IG(7)=IG(3)+10000
ISN 0090            IG(8)=IG(4)+10000
ISN 0091            JEL=IEL
ISN 0092            JPSOL=IPSOL
ISN 0093            DO 565 J=1,LAYERS
ISN 0094            IF(J.EQ.1) GO TO 567
ISN 0096            JEL=JEL+10000
ISN 0097            JPSOL=JPSOL+10
ISN 0098            DO 566 K=1,8
ISN 0099            IG(K)=IG(K)+10000
ISN 0100        566 CONTINUE
              C     PUNCH CONNECTION CARD
ISN 0101        567 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
              C     INCREMENT CONTINUATION FIELD
ISN 0102            JCONT=ICONT
ISN 0103            ICONT=ICONT+1
              C     PUNCH CONTINUATION OF CONNECTION CARD
ISN 0104            WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0105        565 CONTINUE
              C     INCREMENT ELEMENT ID
ISN 0106            IEL=IEL+1
              C     KEEP GOING TILL WE HIT THE CUTOUT
ISN 0107            GO TO 490
              C     IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
ISN 0108        580 YY=-DSQRT(RADIUS**2-X**2)
              C     TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0109            XXMOD=YY+HT2
ISN 0110            YMOD(1)=Z(1)
ISN 0111            ZMOD=X
ISN 0112            WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0113            DO 585 I=2,LAYERG
ISN 0114            YMOD(I)=Z(I)
ISN 0115            WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0116            JGRID=JGRID+10000
ISN 0117        585 CONTINUE
              C     STORE GRID ID
```

```
ISN 0118          JLAST=JLAST+1
ISN 0119          LAST(JLAST)=IGRID
            C     INCREMENT GRID ID
ISN 0120          IGRID=IGRID+1
ISN 0121          JGRID=IGRID+10000
ISN 0122          GO TO 590
            C
            C     WE'VE HIT THE CUTOUT, SO GENERATE
            C     A GRID POINT ON THE CURVE OF THE CUTOUT
            C     WE'RE ABOVE THE 45, SO MOVE IN THE Y-DIRECTION
ISN 0123      560 Y(1)=DSQRT(RADIUS**2-X**2)
ISN 0124          GO TO 570
            C     WE'RE BELOW THE 45 SO MOVE IN THE X-DIRECTION
ISN 0125      480 X=DSQRT(RADIUS**2-Y(1)**2)
ISN 0126      570 YY=-Y(1)
            C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0127          XXMOD=YY+HT2
ISN 0128          YMOD(1)=Z(1)
ISN 0129          ZMOD=X
ISN 0130          WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0131          DO 575 I=2,LAYERG
ISN 0132          YMOD(I)=Z(I)
ISN 0133          WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0134          JGRID=JGRID+10000
ISN 0135      575 CONTINUE
            C     STORE GRID ID
ISN 0136          JCUR=JCUR+1
ISN 0137          ICUR(JCUR)=IGRID
            C     INCREMENT GRID ID'S
ISN 0138          IGRID=IGRID+1
ISN 0139          JGRID=IGRID+10000
            C     IF THIS IS THE FIRST LINE OF GRIDS, DON'T GENERATE CONNECTIONS
ISN 0140          IF(Y(1).EQ.0.0)GO TO 530
            C     DID WE CROSS A LINE OF GRIDS?
ISN 0142          IF(XSAVE.NE.XLAST)GO TO 500
            C     WE DIDN'T CROSS A LINE OF GRIDS SO
            C     GENERATE A QUAD ELEMENT
            C     FIRST SET UP THE GRID ORDER
ISN 0144          IG(1)=ICUR(JCUR)
ISN 0145          IG(2)=ICUR(JCUR-1)
ISN 0146          IG(3)=LAST(JCUR-1)
ISN 0147          IG(4)=LAST(JCUR)
ISN 0148          IG(5)=IG(1)+10000
ISN 0149          IG(6)=IG(2)+10000
ISN 0150          IG(7)=IG(3)+10000
ISN 0151          IG(8)=IG(4)+10000
ISN 0152          JEL=IEL
ISN 0153          JPSOL=IPSOL
ISN 0154          DO 576 J=1,LAYERS
ISN 0155          IF(J.EQ.1)GO TO 578
ISN 0157          JPSOL=JPSOL+10
ISN 0158          JEL=JEL+10000
ISN 0159          DO 577 K=1,8
ISN 0160          IG(K)=IG(K)+10000
```

```
ISN 0161      577 CONTINUE
          C       PUNCH CONNECTION CARD
ISN 0162      578 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
          C       INCREMENT CONTINUATION FIELD
ISN 0163          JCONT=ICONT
ISN 0164          ICONT=ICONT+1
          C       PUNCH CONTINUATION OF CONNECTION CARD
ISN 0165          WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0166      576 CONTINUE
          C       INCREMENT ELEMENT ID
ISN 0167          IEL=IEL+1
ISN 0168          GO TO 530
          C
          C       WE CROSSED A LINE OF GRIDS SO WE NEED A TRIANGULAR
          C       ELEMENT INSTEAD OF A QUAD ELEMENT
          C       FIRST SET UP THE GRID ORDER
ISN 0169      500 IG(1)=ICUR(JCUR-1)
ISN 0170          IG(2)=LAST(JCUR-1)
ISN 0171          IG(3)=ICUR(JCUR)
ISN 0172          IG(4)=IG(1)+10000
ISN 0173          IG(5)=IG(2)+10000
ISN 0174          IG(6)=IG(3)+10000
ISN 0175          JEL=IEL
ISN 0176          JPSOL=IPSOL
ISN 0177          DO 505 J=1,LAYERS
ISN 0178          IF(J.EQ.1) GO TO 507
ISN 0180          JPSOL=JPSOL+10
ISN 0181          JEL=JEL+10000
ISN 0182          DO 506 K=1,6
ISN 0183          IG(K)=IG(K)+10000
ISN 0184      506 CONTINUE
          C       PUNCH CONNECTION CARD
ISN 0185      507 WRITE(7,4)JEL,JPSOL,(IG(I),I=1,6)
ISN 0186        4 FORMAT('CPENTA  ',8I8)
ISN 0187      505 CONTINUE
          C       INCREMENT ELEMENT ID
ISN 0188          IEL=IEL+1
          C       SAVE LAST X AND Y VALUES
ISN 0189      530 YLAST=YSAVE
ISN 0190          XLAST=XSAVE
          C       NOW MOVE CURRENT GRIDS TO LAST GRIDS
ISN 0191          DO 510 I=1,JCUR
ISN 0192          LAST(I)=ICUR(I)
ISN 0193      510 CONTINUE
ISN 0194          JLAST=JCUR
          C       RESET CURRENT GRID COUNTER
ISN 0195          JCUR=0
          C       MOVE UP A LINE
ISN 0196          IF(ANGLE.GT.PIDN4)Y(1)=YSAVE
ISN 0198          Y(1)=Y(1)+DELTY2
          C       ARE WE AT THE TOP OF THE CUTOUT?
ISN 0199          IF(Y(1).LT.(RADIUS+TOLER))GO TO 430
          C       START GOING UP IN THE Y-DIRECTION UNTIL WE HIT THE TOP
          C       START AT THE LEFT EDGE
```

```
ISN 0201          Y(1)=Y(1)-DELTY2
ISN 0202          GO TO 475
ISN 0203      420 X=WIDTH
            C     GENERATE NEXT LINE OF GRID POINTS
ISN 0204          IEND=0
ISN 0205      440 YY=-Y(1)
            C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0206          XXMOD=YY+HT2
ISN 0207          YMOD(1)=Z(1)
ISN 0208          ZMOD=X
ISN 0209          WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0210          DO 445 I=2,LAYERG
ISN 0211          YMOD(I)=Z(I)
ISN 0212          WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0213          JGRID=JGRID+10000
ISN 0214      445 CONTINUE
            C     SAVE GRID ID'S FOR ELEMENT CONNECTIONS
ISN 0215          JCUR=JCUR+1
ISN 0216          ICUR(JCUR)=IGRID
            C     INCREMENT GRID ID'S
ISN 0217          IGRID=IGRID+1
ISN 0218          JGRID=IGRID+10000
            C     SEE IF THERE IS A POINT NEXT TO THIS ONE
ISN 0219          IF (JCUR.GT.JLAST)GO TO 452
            C     MOVE TO THE RIGHT ONE INCREMENT AND REPEAT
ISN 0221      451 X=X-DELTAX
ISN 0222          IF(X.GT.TOLER)GO TO 440
            C     MAKE SURE WE GET THE RIGHT EDGE
ISN 0224          IF(IEND.EQ.1)GO TO 450
ISN 0226          X=0.0
ISN 0227          IEND=1
ISN 0228          GO TO 440
            C
            C     GENERATE ELEMENT CONNECTIONS
            C
ISN 0229      450 DO 460 I=2,JLAST
            C     FIRST SET UP THE GRID POINT ORDER
ISN 0230          IG(1)=ICUR(I)
ISN 0231          IG(2)=ICUR(I-1)
ISN 0232          IG(3)=LAST(I-1)
ISN 0233          IG(4)=LAST(I)
ISN 0234          IG(5)=IG(1)+10000
ISN 0235          IG(6)=IG(2)+10000
ISN 0236          IG(7)=IG(3)+10000
ISN 0237          IG(8)=IG(4)+10000
ISN 0238          JEL=IEL
ISN 0239          JPSOL=IPSOL
ISN 0240          DO 455 K=1,LAYERS
ISN 0241          IF(K.EQ.1) GO TO 457
ISN 0243          JEL=JEL+10000
ISN 0244          JPSOL=JPSOL+10
ISN 0245          DO 456 L=1,8
ISN 0246          IG(L)=IG(L)+10000
ISN 0247      456 CONTINUE
```

```
              C      PUNCH CONNECTION CARD
ISN 0248       457 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
              C      INCREMENT CONTINUATION FIELD
ISN 0249           JCONT=ICONT
ISN 0250           ICONT=ICONT+1
              C      PUNCH CONTINUATION OF CONNECTION CARD
ISN 0251           WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0252         2 FORMAT('CHEXA    ',8I8,'+',I7)
ISN 0253         3 FORMAT('+',I7,2I8)
ISN 0254       455 CONTINUE
              C      INCREMENT ELEMENT ID
ISN 0255           IEL=IEL+1
ISN 0256       460 CONTINUE
              C      MOVE CURRENT LINE OF GRIDS TO LAST LINE
ISN 0257           DO 470 I=1,JCUR
ISN 0258           LAST(I)=ICUR(I)
ISN 0259       470 CONTINUE
ISN 0260           JLAST=JCUR
              C      MAKE CURRENT LINE EMPTY
ISN 0261           JCUR=0
              C      MOVE UP A LINE
ISN 0262       475 Y(1)=Y(1)+DELTY2
              C      HAVE WE HIT THE TOP YET?
ISN 0263           IF(Y(1).LT.(HT2-TOLER))GO TO 420
ISN 0265           IF(IEND2.EQ.1)GO TO 600
ISN 0267           IEND2=1
ISN 0268           Y(1)=HT2
ISN 0269           GO TO 420
              C      IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
ISN 0270       452 YY=-DSQRT(RADIUS**2-X**2)
              C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0271           XXMOD=YY+HT2
ISN 0272           YMOD(1)=Z(1)
ISN 0273           ZMOD=X
ISN 0274           WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0275           DO 453 I=2,LAYERG
ISN 0276           YMOD(I)=Z(I)
ISN 0277           WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0278           JGRID=JGRID+10000
ISN 0279       453 CONTINUE
              C      STORE GRID ID
ISN 0280           JLAST=JLAST+1
ISN 0281           LAST(JLAST)=IGRID
              C      INCREMENT GRID ID
ISN 0282           IGRID=IGRID+1
ISN 0283           JGRID=IGRID+10000
ISN 0284           GO TO 451
ISN 0285       600 IGRID=(IGRID/1000+1)*1000+1
ISN 0286           JGRID=IGRID+10000
ISN 0287           IEL=(IEL/1000+1)*1000+1
ISN 0288           XLAST=XX
ISN 0289           IEND2=0
              C
              C
```

```
                C     GENERATE FIRST PIECE WITH CUTOUT IN IT
                C
                C
                C
                C     START AT THE LOWER LEFTHAND CORNER
                C     THEN MOVE TO THE RIGHT UNTIL WE HIT THE CUTOUT
ISN 0290              Y(1)=DELTAY
ISN 0291           30 X=WIDTH
                C     GENERATE FAR LEFT GRID POINT
                C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0292              XMOD(1)=Y(1)+HT2
ISN 0293              YMOD(1)=Z(1)
ISN 0294              ZMOD=X
ISN 0295              WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
ISN 0296              DO 95 I=2,LAYERG
ISN 0297              YMOD(I)=Z(I)
ISN 0298              WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
ISN 0299              JGRID=JGRID+10000
ISN 0300           95 CONTINUE
                C     STORE GRID ID
ISN 0301              JCUR=JCUR+1
ISN 0302              ICUR(JCUR)=IGRID
                C     IF FIRST LINE OF GRIDS PICK UP GRID # FOR LAST LINE
ISN 0303              IF(Y(1).EQ.DELTAY)LAST(JCUR)=MOD(IGRID,1000)
ISN 0305              IF(Y(1).EQ.DELTAY)JLAST=JCUR
                C     INCREMENT GRID ID
ISN 0307              IGRID=IGRID+1
ISN 0308              JGRID=IGRID+10000
                C     MOVE TO THE LEFT
ISN 0309           90 X=X-DELTAX
                C     SAVE X AND Y
ISN 0310              XSAVE=X
ISN 0311              YSAVE=Y(1)
                C     ARE WE PAST THE 45?
ISN 0312              ANGLE=DATAN(Y(1)/X)
ISN 0313              IF(ANGLE.GT.PION4)GO TO 140
                C     BELOW THE 45
                C     FIND DISTANCE FROM CUTOUT
ISN 0315              IF(Y(1).GT.RADIUS)GO TO 150
ISN 0317              DIST=X-DSQRT(RADIUS**2-Y(1)**2)
                C     ARE WE WITHIN TOLERANCE FROM THE CUTOUT
ISN 0318              IF(DIST.LE.TOLER)GO TO 80
ISN 0320              GO TO 150
                C     ABOVE THE 45
ISN 0321          140 IF(X.GT.RADIUS)GO TO 150
ISN 0323              DIST=Y(1)-DSQRT(RADIUS**2-X**2)
ISN 0324              IF(DIST.LE.TOLER)GO TO 160
                C     NOT AT THE CUTOUT YET SO GENERATE NORMAL GRID POINT
                C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0326          150 XMOD(1)=Y(1)+HT2
ISN 0327              YMOD(1)=Z(1)
ISN 0328              ZMOD=X
ISN 0329              WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
ISN 0330              DO 155 I=2,LAYERG
```

```
ISN 0331        YMOD(I)=Z(I)
ISN 0332        WRITE(7,1)JGRID,XMOD(I),YMOD(I),ZMOD
ISN 0333        JGRID=JGRID+10000
ISN 0334   155  CONTINUE
                STORE GRID ID
ISN 0335        JCUR=JCUR+1
ISN 0336        ICUR(JCUR)=IGRID
                IF FIRST LINE OF GRIDS, PICK UP GRID # FOR LAST LINE
ISN 0337        IF(Y(1).EQ.DELTAY)LAST(JCUR)=MOD(IGRID,1000)
ISN 0339        IF(Y(1).EQ.DELTAY)JLAST=JCUR
                INCREMENT GRID ID'S
ISN 0341        IGRID=IGRID+1
ISN 0342        JGRID=IGRID+10000
                MAKE SURE WE HAVE A POINT NEXT TO THIS ONE
ISN 0343        IF(JCUR.GT.JLAST)GO TO 180
                GENERATE QUAD ELEMENT
                FIRST SET UP GRID POINT ORDER
ISN 0345   190  IG(1)=LAST(JCUR)
ISN 0346        IG(2)=LAST(JCUR-1)
ISN 0347        IG(3)=ICUR(JCUR-1)
ISN 0348        IG(4)=ICUR(JCUR)
ISN 0349        IG(5)=IG(1)+10000
ISN 0350        IG(6)=IG(2)+10000
ISN 0351        IG(7)=IG(3)+10000
ISN 0352        IG(8)=IG(4)+10000
ISN 0353        JEL=IEL
ISN 0354        JPSOL=IPSOL
ISN 0355        DO 165 J=1,LAYERS
ISN 0356        IF(J.EQ.1) GO TO 167
ISN 0358        JEL=JEL+10000
ISN 0359        JPSOL=JPSOL+10
ISN 0360        DO 166 K=1,8
ISN 0361        IG(K)=IG(K)+10000
ISN 0362   166  CONTINUE
                PUNCH CONNECTION CARD
ISN 0363   167  WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
                INCREMENT CONTINUATION FIELD
ISN 0364        JCONT=ICONT
ISN 0365        ICONT=ICONT+1
                PUNCH CONTINUATION OF CONNECTION CARD
ISN 0366        WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0367   165  CONTINUE
                INCREMENT ELEMENT ID
ISN 0368        IEL=IEL+1
                KEEP GOING TILL WE HIT THE CUTOUT
ISN 0369        GO TO 90
                IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
ISN 0370   180  YY=+DSQRT(RADIUS**2-X**2)
               TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0371        XXMOD=YY+HT2
ISN 0372        YMOD(1)=Z(1)
ISN 0373        ZMOD=X
ISN 0374        WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0375        DO 185 I=2,LAYERG
```

```
ISN 0376          YMOD(I)=Z(I)
ISN 0377          WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0378          JGRID=JGRID+10000
ISN 0379      185 CONTINUE
            C     STORE GRID ID
ISN 0380          JLAST=JLAST+1
ISN 0381          LAST(JLAST)=IGRID
            C     INCREMENT GRID ID
ISN 0382          IGRID=IGRID+1
ISN 0383          JGRID=IGRID+10000
ISN 0384          GO TO 190
            C
            C     WE'VE HIT THE CUTOUT, SO GENERATE
            C     A GRID POINT ON THE CURVE OF THE CUTOUT
            C     WE'RE ABOVE THE 45, SO MOVE IN THE Y-DIRECTION
ISN 0385      160 Y(1)=DSQRT(RADIUS**2-X**2)
ISN 0386          GO TO 170
            C     WE'RE BELOW THE 45 SO MOVE IN THE X-DIRECTION
ISN 0387       80 X=DSQRT(RADIUS**2-Y(1)**2)
            C     TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0388      170 XMOD(1)=Y(1)+HT2
ISN 0389          YMOD(1)=Z(1)
ISN 0390          ZMOD=X
ISN 0391          WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
ISN 0392          DO 175 I=2,LAYERG
ISN 0393          YMOD(I)=Z(I)
ISN 0394          WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
ISN 0395          JGRID=JGRID+10000
ISN 0396      175 CONTINUE
            C     STORE GRID ID
ISN 0397          JCUR=JCUR+1
ISN 0398          ICUR(JCUR)=IGRID
            C     IF FIRST LINE OF GRIDS, PICK UP GRID # FOR LAST LINE
ISN 0399          IF(Y(1).EQ.DELTAY)LAST(JCUR)=MOD(IGRID,1000)
ISN 0401          IF(Y(1).EQ.DELTAY)JLAST=JCUR
            C     INCREMENT GRID ID'S
ISN 0403          IGRID=IGRID+1
ISN 0404          JGRID=IGRID+10000
            C     DID WE CROSS A LINE OF GRIDS?
ISN 0405          IF(XSAVE.NE.XLAST)GO TO 100
            C     WE DIDN'T CROSS A LINE OF GRIDS SO
            C     GENERATE A QUAD ELEMENT
            C     FIRST SET UP THE GRID ORDER
ISN 0407          IG(1)=LAST(JCUR)
ISN 0408          IG(2)=LAST(JCUR-1)
ISN 0409          IG(3)=ICUR(JCUR-1)
ISN 0410          IG(4)=ICUR(JCUR)
ISN 0411          IG(5)=IG(1)+10000
ISN 0412          IG(6)=IG(2)+10000
ISN 0413          IG(7)=IG(3)+10000
ISN 0414          IG(8)=IG(4)+10000
ISN 0415          JEL=IEL
ISN 0416          JPSOL=IPSOL
ISN 0417          DO 176 J=1,LAYERS
```

```
ISN 0418          IF(J.EQ.1)GO TO 178
ISN 0420          JPSOL=JPSOL+10
ISN 0421          JEL=JEL+10000
ISN 0422          DO 177 K=1,8
ISN 0423          IG(K)=IG(K)+10000
ISN 0424      177 CONTINUE
            C     PUNCH CONNECTION CARD
ISN 0425      178 WRITE(7,2)JEL,JPSOL,(IG(I),I=1,6),ICONT
            C     INCREMENT CONTINUATION FIELD
ISN 0426          JCONT=ICONT
ISN 0427          ICONT=ICONT+1
            C     PUNCH CONTINUATION OF CONNECTION CARD
ISN 0428          WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0429      176 CONTINUE
            C     INCREMENT ELEMENT ID
ISN 0430          IEL=IEL+1
ISN 0431          GO TO 130
            C
            C     WE CROSSED A LINE OF GRIDS SO WE NEED A TRIANGULAR
            C     ELEMENT INSTEAD OF A QUAD ELEMENT
            C     FIRST SET UP THE GRID ORDER
ISN 0432      100 IG(1)=LAST(JCUR-1)
ISN 0433          IG(2)=ICUR(JCUR-1)
ISN 0434          IG(3)=ICUR(JCUR)
ISN 0435          IG(4)=IG(1)+10000
ISN 0436          IG(5)=IG(2)+10000
ISN 0437          IG(6)=IG(3)+10000
ISN 0438          JEL=IEL
ISN 0439          JPSOL=IPSOL
ISN 0440          DO 105 J=1,LAYERS
ISN 0441          IF(J.EQ.1) GO TO 107
ISN 0443          JPSOL=JPSOL+10
ISN 0444          JEL=JEL+10000
ISN 0445          DO 106 K=1,6
ISN 0446          IG(K)=IG(K)+10000
ISN 0447      106 CONTINUE
            C     PUNCH CONNECTION CARD
ISN 0448      107 WRITE(7,4)JEL,JPSOL,(IG(I),I=1,6)
ISN 0449      105 CONTINUE
            C     INCREMENT ELEMENT ID
ISN 0450          IEL=IEL+1
            C     SAVE LAST X AND Y VALUES
ISN 0451      130 YLAST=YSAVE
ISN 0452          XLAST=XSAVE
            C     NOW MOVE CURRENT GRIDS TO LAST GRIDS
ISN 0453          DO 110 I=1,JCUR
ISN 0454          LAST(I)=ICUR(I)
ISN 0455      110 CONTINUE
ISN 0456          JLAST=JCUR
            C     RESET CURRENT GRID COUNTER
ISN 0457          JCUR=0
            C     MOVE UP A LINE
ISN 0458          IF(ANGLE.GT.PION4)Y(1)=YSAVE
ISN 0460          Y(1)=Y(1)+DELTAY
```

```
                C     ARE WE AT THE TOP OF THE CUTOUT?
ISN 0461              IF(Y(1).LT.(RADIUS+TOLER))GO TO 30
                C     START GOING UP IN THE Y-DIRECTION UNTIL WE HIT THE TOP
                C     START AT THE LEFT EDGE
ISN 0463              Y(1)=Y(1)-DELTAY
ISN 0464              GO TO 75
ISN 0465           20 X=WIDTH
                C     GENERATE NEXT LINE OF GRID POINTS
ISN 0466              IEND=0
                C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0467           40 XMOD(1)=Y(1)+HT2
ISN 0468              YMOD(1)=Z(1)
ISN 0469              ZMOD=X
ISN 0470              WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
ISN 0471              DO  45 I=2,LAYERG
ISN 0472              YMOD(I)=Z(I)
ISN 0473              WRITE(7,1)JGRID,XMOD(1),YMOD(I),ZMOD
ISN 0474              JGRID=JGRID+10000
ISN 0475           45 CONTINUE
                C     SAVE GRID ID'S FOR ELEMENT CONNECTIONS
ISN 0476              JCUR=JCUR+1
ISN 0477              ICUR(JCUR)=IGRID
                C     INCREMENT GRID ID'S
ISN 0478              IGRID=IGRID+1
ISN 0479              JGRID=IGRID+10000
                C     SEE IF THERE IS A POINT NEXT TO THIS ONE
ISN 0480              IF (JCUR.GT.JLAST)GO TO 52
                C     MOVE TO THE RIGHT ONE INCREMENT AND REPEAT
ISN 0482           51 X=X-DELTAX
ISN 0483              IF(X.GT.TOLER)GO TO 40
                C     MAKE SURE WE GET THE RIGHT EDGE
ISN 0485              IF(IEND.EQ.1)GO TO 50
ISN 0487              X=0.0
ISN 0488              IEND=1
ISN 0489              GO TO 40
                C
                C     GENERATE ELEMENT CONNECTIONS
                C
ISN 0490           50 DO 60 I=2,JLAST
                C     FIRST SET UP THE GRID POINT ORDER
ISN 0491              IG(1)=LAST(I)
ISN 0492              IG(2)=LAST(I-1)
ISN 0493              IG(3)=ICUR(I-1)
ISN 0494              IG(4)=ICUR(I)
ISN 0495              IG(5)=IG(1)+10000
ISN 0496              IG(6)=IG(2)+10000
ISN 0497              IG(7)=IG(3)+10000
ISN 0498              IG(8)=IG(4)+10000
ISN 0499              JEL=IEL
ISN 0500              JPSOL=IPSOL
ISN 0501              DO 55 K=1,LAYERS
ISN 0502              IF(K.EQ.1) GO TO 57
ISN 0504              JEL=JEL+10000
ISN 0505              JPSOL=JPSOL+10
```

```
ISN 0506         DO 56 L=1,8
ISN 0507         IG(L)=IG(L)+10000
ISN 0508      56 CONTINUE
            C    PUNCH CONNECTION CARD
ISN 0509      57 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
            C    INCREMENT CONTINUATION FIELD
ISN 0510         JCONT=ICONT
ISN 0511         ICONT=ICONT+1
            C    PUNCH CONTINUATION OF CONNECTION CARD
ISN 0512         WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0513      55 CONTINUE
            C    INCREMENT ELEMENT ID
ISN 0514         IEL=IEL+1
ISN 0515      60 CONTINUE
            C    MOVE CURRENT LINE OF GRIDS TO LAST LINE
ISN 0516         DO 70 I=1,JCUR
ISN 0517         LAST(I)=ICUR(I)
ISN 0518      70 CONTINUE
ISN 0519         JLAST=JCUR
            C    MAKE CURRENT LINE EMPTY
ISN 0520         JCUR=0
            C    MOVE UP A LINE
ISN 0521      75 Y(1)=Y(1)+DELTAY
            C    HAVE WE HIT THE TOP YET?
ISN 0522         IF(Y(1).LT.(LEGX1-TOLER))GO TO 20
ISN 0524         IF(IEND2.EQ.1)GO TO 200
ISN 0526         IEND2=1
ISN 0527         Y(1)=LEGX1
ISN 0528         GO TO 20
            C    IF WE DON'T HAVE A POINT NEXT TO THIS ONE PUT ONE ON THE CURVE
ISN 0529      52 YY=+DSQRT(RADIUS**2-X**2)
            C    TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0530         XXMOD=YY+HT2
ISN 0531         YMOD(1)=Z(1)
ISN 0532         ZMOD=X
ISN 0533         WRITE(7,1)IGRID,XXMOD,YMOD(1),ZMOD
ISN 0534         DO 53 I=2,LAYERG
ISN 0535         YMOD(I)=Z(I)
ISN 0536         WRITE(7,1)JGRID,XXMOD,YMOD(I),ZMOD
ISN 0537         JGRID=JGRID+10000
ISN 0538      53 CONTINUE
            C    STORE GRID ID
ISN 0539         JLAST=JLAST+1
ISN 0540         LAST(JLAST)=IGRID
            C    INCREMENT GRID ID
ISN 0541         IGRID=IGRID+1
ISN 0542         JGRID=IGRID+10000
ISN 0543         GO TO 51
            C
            C
            C    END OF FIRST PIECE
            C
            C
            C
```

```
                  C      GENERATE THE 90-DEGREE BEND
                  C
                  C      FIRST ESTABLISH A CYLINDRICAL CO-ORDINATE SYSTEM
ISN 0544      200 X=0.0
ISN 0545          LEGX=HT2+LEGX1
ISN 0546          LEGXP1=LEGX+1.
ISN 0547          LEGY=LEGY
ISN 0548          WRITE(7,201)LEGX,LEGY,LEGX,LEGY,ICONT
ISN 0549      201 FORMAT('CORD2C ',5X,'100',8X,2F8.4,5X,'0.0',2F8.4,5X,'1.0+',
                 *I7)
ISN 0550          JCONT=ICONT
ISN 0551          ICONT=ICONT+1
ISN 0552          WRITE(7,202)JCONT,LEGXP1,LEGY
ISN 0553      202 FORMAT('+',I7,2F8.4,5X,'0.0')
                  C      SET INITIAL VALUES
ISN 0554          IPSOL=IPSOL+1
ISN 0555          R(1)=BEND
ISN 0556          DO 205 I=2,LAYERG
ISN 0557          R(I)=R(I-1)+T(I-1)
ISN 0558      205 CONTINUE
ISN 0559          THETA=DELTAT
ISN 0560          IEL=((IEL/1000)+1)*1000+1
ISN 0561          IEND2=0
ISN 0562      250 IEND=0
ISN 0563          Z(1)=0.0
                  C      TRANSFORMING FROM ORIGINAL TO MODIFIED CYLINDRICAL COORD SYSTEM
ISN 0564      220 THMOD=90.-THETA
ISN 0565          ZMOD2(1)=WIDTH-Z(1)
ISN 0566          WRITE(7,203)IGRID,R(1),THMOD,ZMOD2(1)
ISN 0567      203 FORMAT('GRID    ',I8,5X,'100',3F8.4)
ISN 0568          DO 225 I=2,LAYERG
ISN 0569          WRITE(7,203)JGRID,R(I),THMOD,ZMOD2(1)
ISN 0570          JGRID=JGRID+10000
ISN 0571      225 CONTINUE
ISN 0572          JCUR=JCUR+1
ISN 0573          ICUR(JCUR)=IGRID
ISN 0574          IGRID=IGRID+1
ISN 0575          JGRID=IGRID+10000
ISN 0576          Z(1)=Z(1)+DELTAX
ISN 0577          IF(Z(1).LT.(WIDTH-TOLER))GO TO 220
                  C      MAKE SURE WE GET THE EDGE
ISN 0579          IF(IEND.EQ.1)GO TO 210
ISN 0581          Z(1)=WIDTH
ISN 0582          IEND=1
ISN 0583          GO TO 220
                  C      GENERATE CONNECTIONS
ISN 0584      210 DO 230 I=2,JCUR
                  C      SET UP THE GRID POINT ORDER
ISN 0585          IG(1)=LAST(I)
ISN 0586          IG(2)=LAST(I-1)
ISN 0587          IG(3)=ICUR(I-1)
ISN 0588          IG(4)=ICUR(I)
ISN 0589          IG(5)=IG(1)+10000
ISN 0590          IG(6)=IG(2)+10000
```

```
ISN 0591           IG(7)=IG(3)+10000
ISN 0592           IG(8)=IG(4)+10000
ISN 0593           JEL=IEL
ISN 0594           JPSOL=IPSOL
ISN 0595           DO 215 K=1,LAYERS
ISN 0596           IF(K.EQ.1)GO TO 217
ISN 0598           JEL=JEL+10000
ISN 0599           JPSOL=JPSOL+10
ISN 0600           DO 216 L=1,8
ISN 0601           IG(L)=IG(L)+10000
ISN 0602       216 CONTINUE
             C     PUNCH CONNECTION CARD
ISN 0603       217 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
             C     INCREMENT CONTINUATION
ISN 0604           JCONT=ICONT
ISN 0605           ICONT=ICONT+1
             C     PUNCH CONTINUATION OF CONNECTION CARD
ISN 0606           WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0607       215 CONTINUE
             C     INCREMENT ELEMENT ID
ISN 0608           IEL=IEL+1
ISN 0609       230 CONTINUE
             C     MOVE CURRENT GRIDS TO LAST GRIDS
ISN 0610           DO 240 I=1,JCUR
ISN 0611           LAST(I)=ICUR(I)
ISN 0612       240 CONTINUE
ISN 0613           JLAST=JCUR
ISN 0614           JCUR=0
             C     INCREMENT ANGLE
ISN 0615           THETA=THETA+DELTAT
ISN 0616           IF(THETA.LT.89.99995)GO TO 250
ISN 0618           IF(IEND2.EQ.1)GO TO 241
ISN 0620           IEND2=1
ISN 0621           THETA=90.
ISN 0622           GO TO 250
             C
             C     END OF 90 DEGREE BEND
             C
             C
             C
             C     START OF BOTTOM PIECE(NO CUTOUT)
             C
             C
             C     INITIALIZE CONSTANTS
ISN 0623       241 IEL=((IEL/1000)+1)*1000+1
ISN 0624           IEND2=0
ISN 0625           IPSOL=IPSOL+1
ISN 0626           Y(1)=LEGX1+BEND
ISN 0627           DO 245 I=2,LAYERG
ISN 0628           Y(I)=Y(I-1)+T(I-1)
ISN 0629       245 CONTINUE
             C     START GOING DOWN IN THE Z-DIRECTION UNTIL WE HIT THE BOTTOM
             C     START AT THE LEFT EDGE
ISN 0630           Z(1)=LEGY-DELTAZ
```

```
ISN 0631     320 X=WIDTH
           C       GENERATE NEXT LINE OF GRID POINTS
ISN 0632           IEND=0
           C     TRANSFORMING FROM ORIGINAL TO MODIFIED RECT COORD SYSTEM
ISN 0633     340 XMOD(1)=Y(1)+HT2
ISN 0634           YMOD(1)=Z(1)
ISN 0635           ZMOD=X
ISN 0636           WRITE(7,1)IGRID,XMOD(1),YMOD(1),ZMOD
ISN 0637           DO 345 I=2,LAYERG
ISN 0638           XMOD(I)=Y(I)+HT2
ISN 0639           WRITE(7,1)JGRID,XMOD(I),YMOD(I),ZMOD
ISN 0640           JGRID=JGRID+10000
ISN 0641     345 CONTINUE
           C       SAVE GRID ID'S FOR ELEMENT CONNECTIONS
ISN 0642           JCUR=JCUR+1
ISN 0643           ICUR(JCUR)=IGRID
           C       INCREMENT GRID ID'S
ISN 0644           IGRID=IGRID+1
ISN 0645           JGRID=IGRID+10000
           C       MOVE TO THE RIGHT ONE INCREMENT AND REPEAT
ISN 0646           X=X-DELTAX
ISN 0647           IF(X.GT.TOLER)GO TO 340
           C       MAKE SURE WE GET THE RIGHT EDGE
ISN 0649           IF(IEND.EQ.1)GO TO 350
ISN 0651           X=0.0
ISN 0652           IEND=1
ISN 0653           GO TO 340
           C
           C       GENERATE ELEMENT CONNECTIONS
           C
ISN 0654     350 DO 360 I=2,JLAST
           C       FIRST SET UP THE GRID POINT ORDER
ISN 0655           IG(1)=LAST(I)
ISN 0656           IG(2)=LAST(I-1)
ISN 0657           IG(3)=ICUR(I-1)
ISN 0658           IG(4)=ICUR(I)
ISN 0659           IG(5)=IG(1)+10000
ISN 0660           IG(6)=IG(2)+10000
ISN 0661           IG(7)=IG(3)+10000
ISN 0662           IG(8)=IG(4)+10000
ISN 0663           JEL=IEL
ISN 0664           JPSOL=IPSOL
ISN 0665           DO 355 K=1,LAYERS
ISN 0666           IF(K.EQ.1)GO TO 357
ISN 0668           JEL=JEL+10000
ISN 0669           JPSOL=JPSOL+10
ISN 0670           DO 356 L=1,8
ISN 0671           IG(L)=IG(L)+10000
ISN 0672     356 CONTINUE
           C       PUNCH CONNECTION CARD
ISN 0673     357 WRITE(7,2)JEL,JPSOL,(IG(J),J=1,6),ICONT
           C       INCREMENT CONTINUATION FIELD
ISN 0674           JCONT=ICONT
ISN 0675           ICONT=ICONT+1
```

```
          C      PUNCH CONTINUATION OF CONNECTION CARD
ISN 0676         WRITE(7,3)JCONT,IG(7),IG(8)
ISN 0677     355 CONTINUE
          C      INCREMENT ELEMENT ID
ISN 0678         IEL=IEL+1
ISN 0679     360 CONTINUE
          C      MOVE CURRENT LINE OF GRIDS TO LAST LINE
ISN 0680         DO 370 I=1,JCUR
ISN 0681         LAST(I)=ICUR(I)
ISN 0682     370 CONTINUE
ISN 0683         JLAST=JCUR
          C      MAKE CURRENT LINE EMPTY
ISN 0684         JCUR=0
          C      MOVE UP A LINE
ISN 0685         Z(1)=Z(1)-DELTAZ
          C      HAVE WE HIT THE BOTTOM YET?
ISN 0686         IF(Z(1).GT.TOLER)GO TO 320
ISN 0688         IF(IEND2.EQ.1)GO TO 120
ISN 0690         IEND2=1
ISN 0691         Z(1)=0.0
ISN 0692         GO TO 320
          C      WERE DONE...WHEW
          C      SO DUMP THE BUFFER
ISN 0693     120 ENDFILE 7
          C      AND GET THE HELL OUT
ISN 0694         STOP
ISN 0695     900 WRITE(6,901)
ISN 0696     901 FORMAT('-***ERROR***  TOO MANY LAYERS SPECIFIED')
ISN 0697         STOP
ISN 0698         END
```

PARAMETER ECHO

```
LEGX1=        0.2700
LEGY=         0.5100
WIDTH=        0.5000
RADIUS=       0.2500
DELTA-Y=      0.0900
DELTA-X=      0.1000
DELTA-T=     15.0000
BEND=         0.1250
TOLERANCE=    0.0150
DELTA-Z=      0.1700
LAYERS=            1
DELTAY2=      0.1330
HEIGHT2=      0.4000
LAYER- 1 THICKNESS= 0.1250
```

APPENDIX F

C-1 MODEL PREPROCESSOR PROGRAM BULK DATA LISTING

BULK DATA GENERATED BY C-1 PREPROCESSOR

1.	GRID		1		0.4000	0.6350	0.5000				
2.	GRID		10001		0.4000	0.7600	0.5000				
3.	GRID		2		0.4000	0.6350	0.4000				
4.	GRID		10002		0.4000	0.7600	0.4000				
5.	GRID		3		0.4000	0.6350	0.3000				
6.	GRID		10003		0.4000	0.7600	0.3000				
7.	GRID		4		0.4000	0.6350	0.2500				
8.	GRID		10004		0.4000	0.7600	0.2500				
9.	GRID		5		0.2670	0.6350	0.5000				
10.	GRID		10005		0.2670	0.7600	0.5000				
11.	GRID		6		0.2670	0.6350	0.4000				
12.	GRID		10006		0.2670	0.7600	0.4000				
13.	CHEXA		1	1	6	5	1	2	10006	10005+	0
14.	+	0	10001	10002							
15.	GRID		7		0.2670	0.6350	0.3000				
16.	GRID		10007		0.2670	0.7600	0.3000				
17.	CHEXA		2	1	7	6	2	3	10007	10006+	1
18.	+	1	10002	10003							
19.	GRID		8		0.2670	0.6350	0.2117				
20.	GRID		10008		0.2670	0.7600	0.2117				
21.	CHEXA		3	1	8	7	3	4	10008	10007+	2
22.	+	2	10003	10004							
23.	GRID		9		0.1340	0.6350	0.5000				
24.	GRID		10009		0.1340	0.7600	0.5000				
25.	GRID		10		0.1340	0.6350	0.4000				
26.	GRID		10010		0.1340	0.7600	0.4000				
27.	GRID		11		0.1340	0.6350	0.3000				
28.	GRID		10011		0.1340	0.7600	0.3000				
29.	GRID		12		0.1340	0.6350	0.2000				
30.	GRID		10012		0.1340	0.7600	0.2000				
31.	GRID		13		0.1340	0.6350	0.1000				
32.	GRID		10013		0.1340	0.7600	0.1000				
33.	GRID		14		0.1709	0.6350	0.1000				
34.	GRID		10014		0.1709	0.7600	0.1000				
35.	GRID		15		0.1340	0.6350	0.0				
36.	GRID		10015		0.1340	0.7600	0.0				
37.	GRID		16		0.1500	0.6350	0.0				
38.	GRID		10016		0.1500	0.7600	0.0				
39.	CHEXA		4	1	10	9	5	6	10010	10009+	3
40.	+	3	10005	10006							
41.	CHEXA		5	1	11	10	6	7	10011	10010+	4
42.	+	4	10006	10007							
43.	CHEXA		6	1	12	11	7	8	10012	10011+	5
44.	+	5	10007	10008							
45.	CHEXA		7	1	13	12	8	14	10013	10012+	6
46.	+	6	10008	10014							
47.	CHEXA		8	1	15	13	14	16	10015	10013+	7
48.	+	7	10014	10016							
49.	GRID		17		0.0	0.6350	0.5000				
50.	GRID		10017		0.0	0.7600	0.5000				
51.	GRID		18		0.0	0.6350	0.4000				
52.	GRID		10018		0.0	0.7600	0.4000				
53.	GRID		19		0.0	0.6350	0.3000				
54.	GRID		10019		0.0	0.7600	0.3000				
55.	GRID		20		0.0	0.6350	0.2000				
56.	GRID		10020		0.0	0.7600	0.2000				
57.	GRID		21		0.0	0.6350	0.1000				
58.	GRID		10021		0.0	0.7600	0.1000				

59.	GRID		22		0.0	0.6350	0.0				
60.	GRID		10022		0.0	0.7600	0.0				
61.	CHEXA		9	1	18	17	9	10	10018	10017+	8
62.	+	8	10009	10010							
63.	CHEXA		10	1	19	18	10	11	10019	10018+	9
64.	+	9	10010	10011							
65.	CHEXA		11	1	20	19	11	12	10020	10019+	10
66.	+	10	10011	10012							
67.	CHEXA		12	1	21	20	12	13	10021	10020+	11
68.	+	11	10012	10013							
69.	CHEXA		13	1	22	21	13	15	10022	10021+	12
70.	+	12	10013	10015							
71.	GRID		1001		0.4900	0.6350	0.5000				
72.	GRID		11001		0.4900	0.7600	0.5000				
73.	GRID		1002		0.4900	0.6350	0.4000				
74.	GRID		11002		0.4900	0.7600	0.4000				
75.	CHEXA		1001	1	2	1	1001	1002	10002	10001+	13
76.	+	13	11001	11002							
77.	GRID		1003		0.4900	0.6350	0.3000				
78.	GRID		11003		0.4900	0.7600	0.3000				
79.	CHEXA		1002	1	3	2	1002	1003	10003	10002+	14
80.	+	14	11002	11003							
81.	GRID		1004		0.4900	0.6350	0.2332				
82.	GRID		11004		0.4900	0.7600	0.2332				
83.	CHEXA		1003	1	4	3	1003	1004	10004	10003+	15
84.	+	15	11003	11004							
85.	GRID		1005		0.5800	0.6350	0.5000				
86.	GRID		11005		0.5800	0.7600	0.5000				
87.	GRID		1006		0.5800	0.6350	0.4000				
88.	GRID		11006		0.5800	0.7600	0.4000				
89.	CHEXA		1004	1	1002	1001	1005	1006	11002	11001+	16
90.	+	16	11005	11006							
91.	GRID		1007		0.5800	0.6350	0.3000				
92.	GRID		11007		0.5800	0.7600	0.3000				
93.	CHEXA		1005	1	1003	1002	1006	1007	11003	11002+	17
94.	+	17	11006	11007							
95.	GRID		1008		0.5800	0.6350	0.2000				
96.	GRID		11008		0.5800	0.7600	0.2000				
97.	CHEXA		1006	1	1004	1003	1007	1008	11004	11003+	18
98.	+	18	11007	11008							
99.	GRID		1009		0.6291	0.6350	0.1000				
100.	GRID		11009		0.6291	0.7600	0.1000				
101.	CPENTA		1007	1	1004	1008	1009	11004	11008	11009	
102.	GRID		1010		0.6700	0.6350	0.5000				
103.	GRID		11010		0.6700	0.7600	0.5000				
104.	GRID		1011		0.6700	0.6350	0.4000				
105.	GRID		11011		0.6700	0.7600	0.4000				
106.	GRID		1012		0.6700	0.6350	0.3000				
107.	GRID		11012		0.6700	0.7600	0.3000				
108.	GRID		1013		0.6700	0.6350	0.2000				
109.	GRID		11013		0.6700	0.7600	0.2000				
110.	GRID		1014		0.6700	0.6350	0.1000				
111.	GRID		11014		0.6700	0.7600	0.1000				
112.	GRID		1015		0.6700	0.6350	0.0				
113.	GRID		11015		0.6700	0.7600	0.0				
114.	GRID		1016		0.6500	0.6350	0.0				
115.	GRID		11016		0.6500	0.7600	0.0				
116.	CHEXA		1008	1	1006	1005	1010	1011	11006	11005+	19
117.	+	19	11010	11011							
118.	CHEXA		1009	1	1007	1006	1011	1012	11007	11006+	20
119.	+	20	11011	11012							

120.	CHEXA		1010	1	1008	1007	1012	1013	11008	11007+	21
121.	+	21	11012	11013							
122.	CHEXA		1011	1	1009	1008	1013	1014	11009	11008+	22
123.	+	22	11013	11014							
124.	CHEXA		1012	1	1010	1009	1014	1015	11010	11009+	23
125.	+	23	11014	11015							
126.	CORD2C		100		0.6700	0.5100	0.0	0.6700	0.5100	1.0+	24
127.	+	24	1.6700	0.5100	0.0						
128.	GRID		1017	100	0.1250	75.0000	0.5000				
129.	GRID		11017	100	0.2500	75.0000	0.5000				
130.	GRID		1018	100	0.1250	75.0000	0.4000				
131.	GRID		11018	100	0.2500	75.0000	0.4000				
132.	GRID		1019	100	0.1250	75.0000	0.3000				
133.	GRID		11019	100	0.2500	75.0000	0.3000				
134.	GRID		1020	100	0.1250	75.0000	0.2000				
135.	GRID		11020	100	0.2500	75.0000	0.2000				
136.	GRID		1021	100	0.1250	75.0000	0.1000				
137.	GRID		11021	100	0.2500	75.0000	0.1000				
138.	GRID		1022	100	0.1250	75.0000	0.0				
139.	GRID		11022	100	0.2500	75.0000	0.0				
140.	CHEXA		2001	2	1011	1010	1017	1018	11011	11010+	25
141.	+	25	11017	11018							
142.	CHEXA		2002	2	1012	1011	1018	1019	11012	11011+	26
143.	+	26	11018	11019							
144.	CHEXA		2003	2	1013	1012	1019	1020	11013	11012+	27
145.	+	27	11019	11020							
146.	CHEXA		2004	2	1014	1013	1020	1021	11014	11013+	28
147.	+	28	11020	11021							
148.	CHEXA		2005	2	1015	1014	1021	1022	11015	11014+	29
149.	+	29	11021	11022							
150.	GRID		1023	100	0.1250	60.0000	0.5000				
151.	GRID		11023	100	0.2500	60.0000	0.5000				
152.	GRID		1024	100	0.1250	60.0000	0.4000				
153.	GRID		11024	100	0.2500	60.0000	0.4000				
154.	GRID		1025	100	0.1250	60.0000	0.3000				
155.	GRID		11025	100	0.2500	60.0000	0.3000				
156.	GRID		1026	100	0.1250	60.0000	0.2000				
157.	GRID		11026	100	0.2500	60.0000	0.2000				
158.	GRID		1027	100	0.1250	60.0000	0.1000				
159.	GRID		11027	100	0.2500	60.0000	0.1000				
160.	GRID		1028	100	0.1250	60.0000	0.0				
161.	GRID		11028	100	0.2500	60.0000	0.0				
162.	CHEXA		2006	2	1018	1017	1023	1024	11018	11017+	30
163.	+	30	11023	11024							
164.	CHEXA		2007	2	1019	1018	1024	1025	11019	11018+	31
165.	+	31	11024	11025							
166.	CHEXA		2008	2	1020	1019	1025	1026	11020	11019+	32
167.	+	32	11025	11026							
168.	CHEXA		2009	2	1021	1020	1026	1027	11021	11020+	33
169.	+	33	11026	11027							
170.	CHEXA		2010	2	1022	1021	1027	1028	11022	11021+	34
171.	+	34	11027	11028							
172.	GRID		1029	100	0.1250	45.0000	0.5000				
173.	GRID		11029	100	0.2500	45.0000	0.5000				
174.	GRID		1030	100	0.1250	45.0000	0.4000				
175.	GRID		11030	100	0.2500	45.0000	0.4000				
176.	GRID		1031	100	0.1250	45.0000	0.3000				
177.	GRID		11031	100	0.2500	45.0000	0.3000				
178.	GRID		1032	100	0.1250	45.0000	0.2000				
179.	GRID		11032	100	0.2500	45.0000	0.2000				
180.	GRID		1033	100	0.1250	45.0000	0.1000				

GRID		11033	100	0.2500	45.0000	0.1000			
GRID		1034	100	0.1250	45.0000	0.0			
GRID		11034	100	0.2500	45.0000	0.0			
CHEXA		2011	2	1024	1023	1029	1030	11024	11023+ 35
+	35	11029	11030						
CHEXA		2012	2	1025	1024	1030	1031	11025	11024+ 36
+	36	11030	11031						
CHEXA		2013	2	1026	1025	1031	1032	11026	11025+ 37
+	37	11031	11032						
CHEXA		2014	2	1027	1026	1032	1033	11027	11026+ 38
+	38	11032	11033						
CHEXA		2015	2	1028	1027	1033	1034	11028	11027+ 39
+	39	11033	11034						
GRID		1035	100	0.1250	30.0000	0.5000			
GRID		11035	100	0.2500	30.0000	0.5000			
GRID		1036	100	0.1250	30.0000	0.4000			
GRID		11036	100	0.2500	30.0000	0.4000			
GRID		1037	100	0.1250	30.0000	0.3000			
GRID		11037	100	0.2500	30.0000	0.3000			
GRID		1038	100	0.1250	30.0000	0.2000			
GRID		11038	100	0.2500	30.0000	0.2000			
GRID		1039	100	0.1250	30.0000	0.1000			
GRID		11039	100	0.2500	30.0000	0.1000			
GRID		1040	100	0.1250	30.0000	0.0			
GRID		11040	100	0.2500	30.0000	0.0			
CHEXA		2016	2	1030	1029	1035	1036	11030	11029+ 40
+	40	11035	11036						
CHEXA		2017	2	1031	1030	1036	1037	11031	11030+ 41
+	41	11036	11037						
CHEXA		2018	2	1032	1031	1037	1038	11032	11031+ 42
+	42	11037	11038						
CHEXA		2019	2	1033	1032	1038	1039	11033	11032+ 43
+	43	11038	11039						
CHEXA		2020	2	1034	1033	1039	1040	11034	11033+ 44
+	44	11039	11040						
GRID		1041	100	0.1250	15.0000	0.5000			
GRID		11041	100	0.2500	15.0000	0.5000			
GRID		1042	100	0.1250	15.0000	0.4000			
GRID		11042	100	0.2500	15.0000	0.4000			
GRID		1043	100	0.1250	15.0000	0.3000			
GRID		11043	100	0.2500	15.0000	0.3000			
GRID		1044	100	0.1250	15.0000	0.2000			
GRID		11044	100	0.2500	15.0000	0.2000			
GRID		1045	100	0.1250	15.0000	0.1000			
GRID		11045	100	0.2500	15.0000	0.1000			
GRID		1046	100	0.1250	15.0000	0.0			
GRID		11046	100	0.2500	15.0000	0.0			
CHEXA		2021	2	1036	1035	1041	1042	11036	11035+ 45
+	45	11041	11042						
CHEXA		2022	2	1037	1036	1042	1043	11037	11036+ 46
+	46	11042	11043						
CHEXA		2023	2	1038	1037	1043	1044	11038	11037+ 47
+	47	11043	11044						
CHEXA		2024	2	1039	1038	1044	1045	11039	11038+ 48
+	48	11044	11045						
CHEXA		2025	2	1040	1039	1045	1046	11040	11039+ 49
+	49	11045	11046						
GRID		1047	100	0.1250	0.0	0.5000			
GRID		11047	100	0.2500	0.0	0.5000			
GRID		1048	100	0.1250	0.0	0.4000			
GRID		11048	100	0.2500	0.0	0.4000			

242.	GRID		1049	100	0.1250	0.0	0.3000				
243.	GRID		11049	100	0.2500	0.0	0.3000				
244.	GRID		1050	100	0.1250	0.0	0.2000				
245.	GRID		11050	100	0.2500	0.0	0.2000				
246.	GRID		1051	100	0.1250	0.0	0.1000				
247.	GRID		11051	100	0.2500	0.0	0.1000				
248.	GRID		1052	100	0.1250	0.0	0.0				
249.	GRID		11052	100	0.2500	0.0	0.0				
250.	CHEXA		2026	2	1042	1041	1047	1048	11042	11041+	50
251.	+	50	11047	11048							
252.	CHEXA		2027	2	1043	1042	1048	1049	11043	11042+	51
253.	+	51	11048	11049							
254.	CHEXA		2028	2	1044	1043	1049	1050	11044	11043+	52
255.	+	52	11049	11050							
256.	CHEXA		2029	2	1045	1044	1050	1051	11045	11044+	53
257.	+	53	11050	11051							
258.	CHEXA		2030	2	1046	1045	1051	1052	11046	11045+	54
259.	+	54	11051	11052							
260.	GRID		1053		0.7950	0.3400	0.5000				
261.	GRID		11053		0.9200	0.3400	0.5000				
262.	GRID		1054		0.7950	0.3400	0.4000				
263.	GRID		11054		0.9200	0.3400	0.4000				
264.	GRID		1055		0.7950	0.3400	0.3000				
265.	GRID		11055		0.9200	0.3400	0.3000				
266.	GRID		1056		0.7950	0.3400	0.2000				
267.	GRID		11056		0.9200	0.3400	0.2000				
268.	GRID		1057		0.7950	0.3400	0.1000				
269.	GRID		11057		0.9200	0.3400	0.1000				
270.	GRID		1058		0.7950	0.3400	0.0				
271.	GRID		11058		0.9200	0.3400	0.0				
272.	CHEXA		3001	3	1048	1047	1053	1054	11048	11047+	55
273.	+	55	11053	11054							
274.	CHEXA		3002	3	1049	1048	1054	1055	11049	11048+	56
275.	+	56	11054	11055							
276.	CHEXA		3003	3	1050	1049	1055	1056	11050	11049+	57
277.	+	57	11055	11056							
278.	CHEXA		3004	3	1051	1050	1056	1057	11051	11050+	58
279.	+	58	11056	11057							
280.	CHEXA		3005	3	1052	1051	1057	1058	11052	11051+	59
281.	+	59	11057	11058							
282.	GRID		1059		0.7950	0.1700	0.5000				
283.	GRID		11059		0.9200	0.1700	0.5000				
284.	GRID		1060		0.7950	0.1700	0.4000				
285.	GRID		11060		0.9200	0.1700	0.4000				
286.	GRID		1061		0.7950	0.1700	0.3000				
287.	GRID		11061		0.9200	0.1700	0.3000				
288.	GRID		1062		0.7950	0.1700	0.2000				
289.	GRID		11062		0.9200	0.1700	0.2000				
290.	GRID		1063		0.7950	0.1700	0.1000				
291.	GRID		11063		0.9200	0.1700	0.1000				
292.	GRID		1064		0.7950	0.1700	0.0				
293.	GRID		11064		0.9200	0.1700	0.0				
294.	CHEXA		3006	3	1054	1053	1059	1060	11054	11053+	60
295.	+	60	11059	11060							
296.	CHEXA		3007	3	1055	1054	1060	1061	11055	11054+	61
297.	+	61	11060	11061							
298.	CHEXA		3008	3	1056	1055	1061	1062	11056	11055+	62
299.	+	62	11061	11062							
300.	CHEXA		3009	3	1057	1056	1062	1063	11057	11056+	63
301.	+	63	11062	11063							
302.	CHEXA		3010	3	1058	1057	1063	1064	11058	11057+	64

303.	+	C4	11063	11064								
304.	GRID		1065		0.7950	0.0	0.5000					
305.	GRID		11065		0.9200	0.0	0.5000					
306.	GRID		1066		0.7950	0.0	0.4000					
307.	GRID		11066		0.9200	0.0	0.4000					
308.	GRID		1067		0.7950	0.0	0.3000					
309.	GRID		11067		0.9200	0.0	0.3000					
310.	GRID		1068		0.7950	0.0	0.2000					
311.	GRID		11068		0.9200	0.0	0.2000					
312.	GRID		1069		0.7950	0.0	0.1000					
313.	GRID		11069		0.9200	0.0	0.1000					
314.	GRID		1070		0.7950	0.0	0.0					
315.	GRID		11070		0.9200	0.0	0.0					
316.	CHEXA		3011	3	1060	1059	1065	1066	11060	11059+	C5
317.	+	C5	11065	11066							
318.	CHEXA		3012	3	1061	1060	1066	1067	11061	11060+	C6
319.	+	C6	11066	11067							
320.	CHEXA		3013	3	1062	1061	1067	1068	11062	11061+	C7
321.	+	C7	11067	11068							
322.	CHEXA		3014	3	1063	1062	1068	1069	11063	11062+	C8
323.	+	C8	11068	11069							
324.	CHEXA		3015	3	1064	1063	1069	1070	11064	11063+	C9
325.	+	C9	11069	11070							

APPENDIX G

G-1 PLOT RUN DATA DECK SETUP AND UNDEDORMED PLOTS

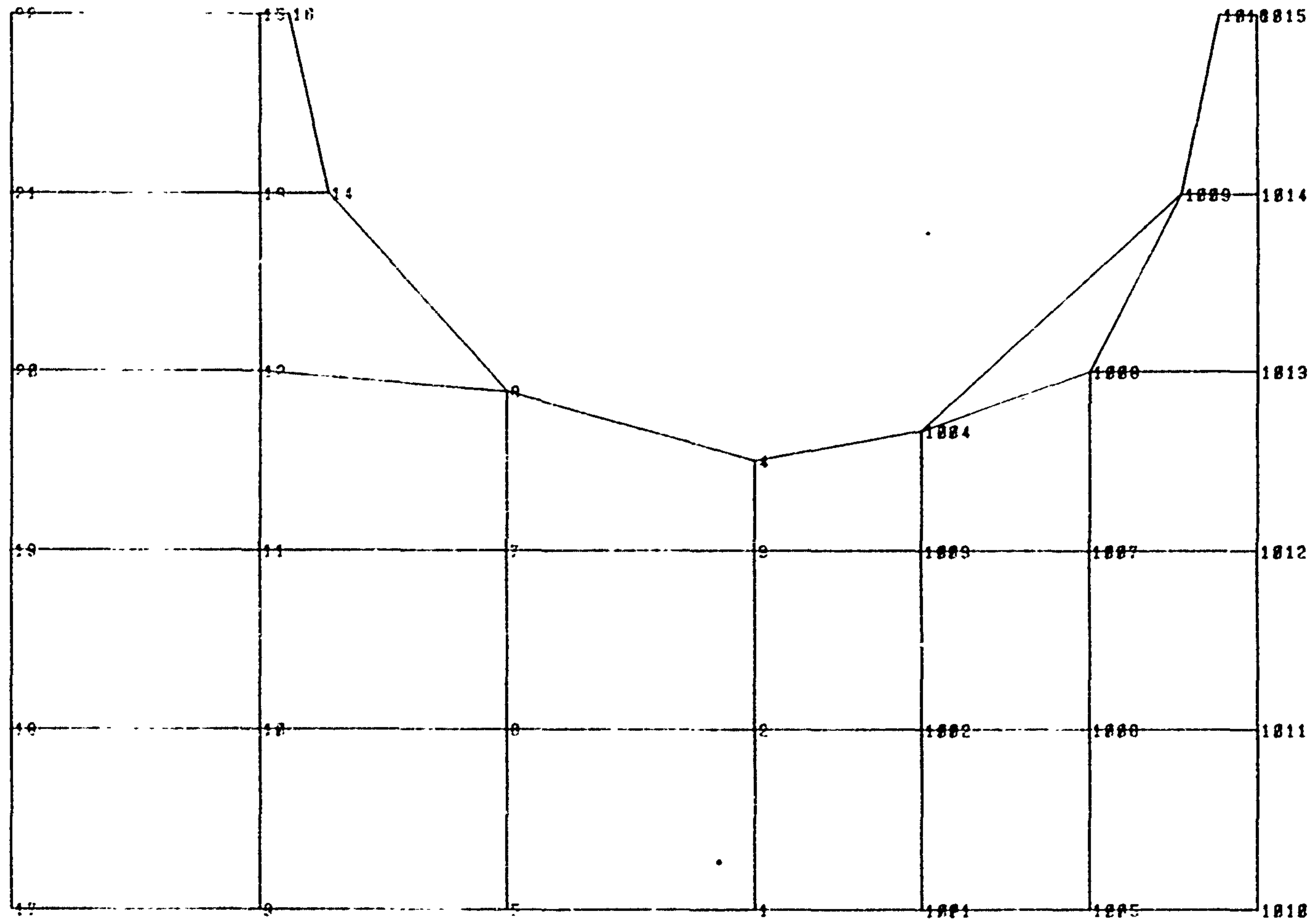
```
// JOB (900004,,048,300),PLOTC14,CLASS=C
//RUN EXEC NAST46,PTAPE=WYLBUR,PLOT=WYL302,
// PLOTDSN='CX900004.SSS.PLOTC14',PLOTPGM=PLOT936,
//      W1=1,KON360=12K,PBUF=141,FBUFF=400,R=299K
ID MODELC1,PLOTC14
SOL 24
TIME 5
DIAG 8,14
ALTER 23 $
EXIT $
ENDALTER
CEND
TITLE = PRE-PROCESSOR PRODUCED GEOMETRY (MODEL C14)
OUTPUT(PLOT)
PLOTTER NASTRAN MODEL 0,0
SET 1 = 1 THRU 1072 EXCLUDE GRID POINTS 10001 THRU 11083
SET 2 = 2001 THRU 2090
SET 3 = 3001 THRU 3050
SET 4 = ALL
$
$ PLOT MESH I
$
AXES Y,X,MZ
VIEW 0.,0.,0.
PTITLE=PART I WITH WASHER: TOP VIEW
FIND SCALE SET 1 ORIGIN 1
PLOT SET 1 ORIGIN 1 LABEL ELEMENTS
PLOT SET 1 ORIGIN 1 LABEL GRIDS
$
AXES Z,X,Y
VIEW 0.,0.,0.
PTITLE=FULL BRACKET: VIEW 0,0,0
FIND SCALE SET 4 ORIGIN 6
PLOT SET 4 ORIGIN 6
$
$ PLOT MESHES I,II, AND III
$
AXES Z,X,Y
VIEW -10.,20.,-30.
PTITLE=FULL BRACKET: 3-D VIEW -10,20,-30
FIND SCALE SET 4 ORIGIN 5
PLOT SET 4 ORIGIN 5
BEGIN BULK
    .
    .
    .
    .
(BULK DATA)
    .
    .
    .
ENDDATA
```

1 8/11/78
TOP VIEW - MESH I WITH WASHER

PRE-PROCESSOR PRODUCED BULK DATA

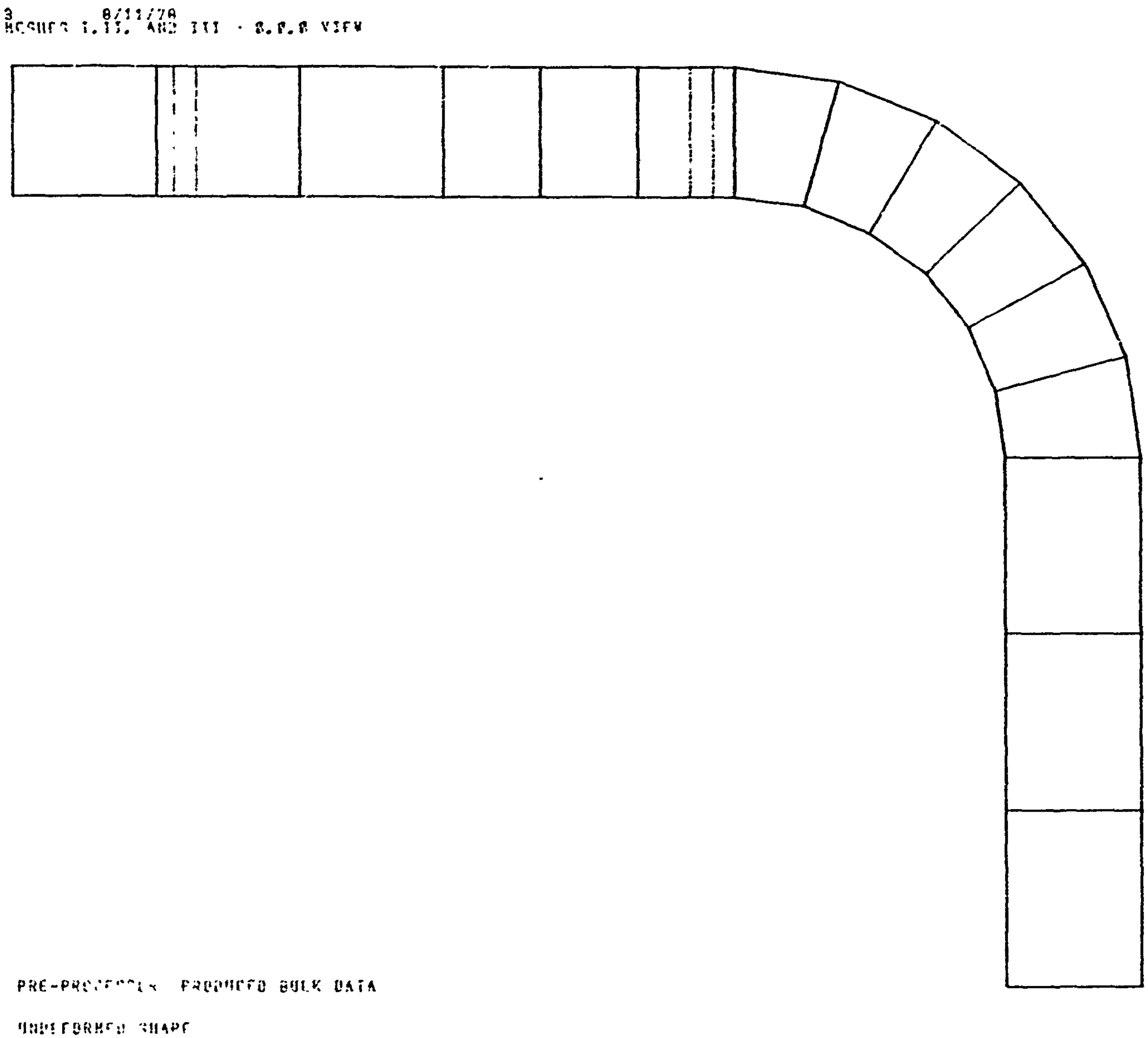
UNDEFORMED SHAPE

2 8/11/78
TOP VIEW - MESH I WITH WASHER

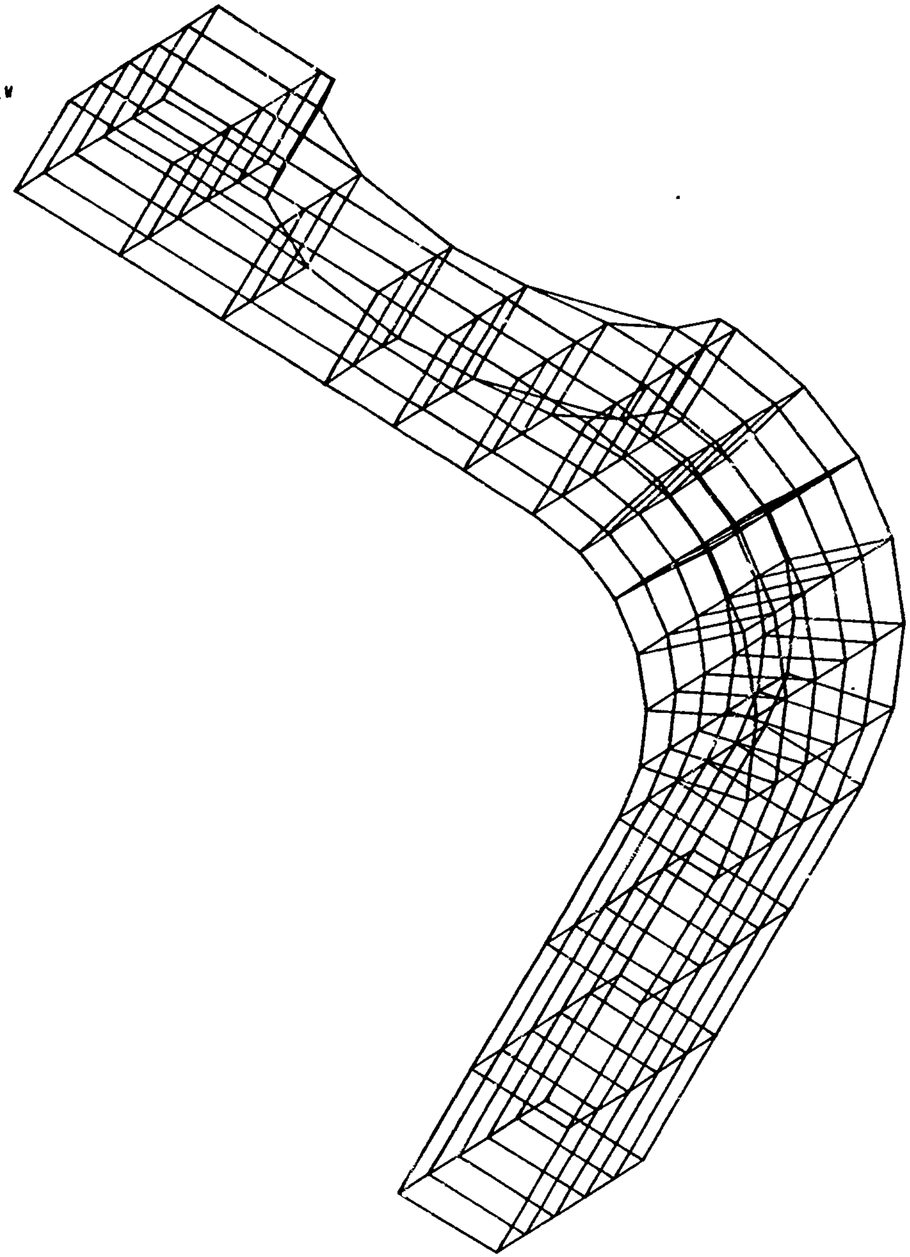


PRE-PROCESSOR PRODUCED BULK DATA

UNDEFORMED SHAPE


3 8/11/78
MESHES I, II, AND III - S.P.S VIEW
PRE-PROCESSOR PRODUCED BULK DATA
UNDEFORMED SHAPE

4 8/11/78
MESHES I.II. AND III -10.20.-30 VIEW



PRE-PROCESSOR PRODUCED BULK DATA

UNDEFORMED SHAPE

APPENDIX H

C-1 SOLUTION RUN OUTPUT

```
* * * * * * * * * * * * * * * * * * * *
* *                                 * *
* *          N A S T R A N          * *
* *                                 * *
* *            MSC - 46             * *
* *                                 * *
* *     VERSION  MAR 11, 1978       * *
* *                                 * *
* *     IBM 360-370  SERIES         * *
* *                                 * *
* *     MODEL      65               * *
* *                                 * *
* * * * * * * * * * * * * * * * * * * *
```

```
     N A S T R A N   S Y S T E M   P A R A M E T E R   E C H O        SEPTEMBER   7, 1978   NASTRAN  0/ 0/ 0

NASTRAN PREFOPT=1
```

```
                                                                      SEPTEMBER   7, 1978   NASTRAN  3/11/78

     N A S T R A N    E X E C U T I V E    C O N T R O L    D E C K    E C H O

ID ADCOMPST,MODELC1B
SOL 24
TIME 60
DIAG 8,14
DIAG 22
CEND
```

```
                         C A S E    C O N T R O L    D E C K    E C H O
        CARD
        COUNT
         1       TITLE = COMPOSIT BRACKET MODEL C18 (PHASE 2)
         2       SUBTITLE = MAT9   M052 (0(13)/45(12)), BR =.125, T =.125
         3       SPC = 9
         4       $
         5       SUBCASE  1    $ DOWNWARD LOAD ALONG ONE LINE
         6       LOAD = 1
         7       $
         8       SUBCASE  2    $ DOWNWARD LOAD ALONG OTHER LINE
         9       LOAD = 2
        10       $
        11       SUBCOM 3
        12       SUBTITLE = UNIFORM PULL
        13       SUBSEQ = 1.0,1.0
        14       OLOAD = ALL
        15       DISPL = ALL
        16       STRESS = ALL
        17       SPCFORCE = ALL
        18       ESE = ALL
        19       GPFORCE = ALL
        20       $
        21       SUBCOM 4
        22       SUBTITLE = COUPLE DUE TO ECCENTRICITY (CLOCKWISE)
        23       SUBSEQ = -1.0, 1.0
        24       OLOAD = ALL
        25       DISPL = ALL
        26       STRESS = ALL
        27       SPCFORCE = ALL
        28       ESE = ALL
        29       GPFORCE = ALL
        30       BEGIN BULK
```

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..		10 .
1-	CHEXA	1	1	2	5	1	2	10006	10005	+	0
2-	+	010001	10002								
3-	CHEXA	2	1	7	6	2	3	10007	10006	+	1
4-	+	110002	10003								
5-	CHEXA	3	1	8	7	3	4	10008	10007	+	2
6-	+	210003	10004								
7-	CHEXA	4	1	10	9	5	6	10010	10009	+	3
8-	+	310005	10006								
9-	CHEXA	5	1	11	10	6	7	10011	10010	+	4
10-	+	410006	10007								
11-	CHEXA	6	1	12	11	7	8	10012	10011	+	5
12-	+	510007	10008								
13-	CHEXA	7	1	13	12	8	14	10013	10012	+	6
14-	+	610008	10014								
15-	CHEXA	8	1	15	13	14	16	10015	10013	+	7
16-	+	710014	10016								
17-	CHEXA	9	1	18	17	9	10	10018	10017	+	8
18-	+	810009	10010								
19-	CHEXA	10	1	19	18	10	11	10019	10018	+	9
20-	+	910010	10011								
21-	CHEXA	11	1	20	19	11	12	10020	10019	+	10
22-	+	1010011	10012								
23-	CHEXA	12	1	21	20	12	13	10021	10020	+	11
24-	+	1110012	10013								
25-	CHEXA	13	1	22	21	13	15	10022	10021	+	12
26-	+	1210013	10015								
27-	CHEXA	1001	1	2	1	1001	1002	10002	10001	+	13
28-	+	1311001	11002								
29-	CHEXA	1002	1	3	2	1002	1003	10003	10002	+	14
30-	+	1411002	11003								
31-	CHEXA	1003	1	4	3	1003	1004	10004	10003	+	15
32-	+	1511003	11004								
33-	CHEXA	1004	1	1002	1001	1005	1006	11002	11001	+	16
34-	+	1611005	11006								
35-	CHEXA	1005	1	1003	1002	1006	1007	11003	11002	+	17
36-	+	1711006	11007								
37-	CHEXA	1006	1	1004	1003	1007	1008	11004	11003	+	18
38-	+	1811007	11008								
39-	CHEXA	1008	1	1006	1005	1010	1011	11006	11005	+	19
40-	+	1911010	11011								
41-	CHEXA	1009	1	1007	1006	1011	1012	11007	11006	+	20
42-	+	2011011	11012								
43-	CHEXA	1010	1	1008	1007	1012	1013	11008	11007	+	21
44-	+	2111012	11013								
45-	CHEXA	1011	1	1009	1008	1013	1014	11009	11008	+	22
46-	+	2211013	11014								
47-	CHEXA	1012	1	1016	1009	1014	1015	11016	11009	+	23
48-	+	2311014	11015								
49-	CHEXA	2001	2	1011	1010	1017	1018	11011	11010	+	25
50-	+	2511017	11018								

COMPOSITE BRACKET PIECE CID (PHASE 2)
PATS HCS2 (0(13)/45(12)), TR =.125, T =.125

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
51-	CHEXA	2002	2	1012	1011	1016	1015	11012	11011	+26
52-	+	2611016	11015							
53-	CHEXA	2003	2	1013	1012	1019	1020	11013	11012	+27
54-	+	2711019	11020							
55-	CHEXA	2004	2	1014	1013	1020	1021	11014	11013	+28
56-	+	2811020	11021							
57-	CHEXA	2005	2	1015	1014	1021	1022	11015	11014	+29
58-	+	2911021	11022							
59-	CHEXA	2006	2	1018	1017	1023	1024	11018	11017	+30
60-	+	3011023	11024							
61-	CHEXA	2007	2	1019	1018	1024	1025	11019	11018	+31
62-	+	3111024	11025							
63-	CHEXA	2008	2	1020	1019	1025	1026	11020	11019	+32
64-	+	3211025	11026							
65-	CHEXA	2009	2	1021	1020	1026	1027	11021	11020	+33
66-	+	3311026	11027							
67-	CHEXA	2010	2	1022	1021	1027	1028	11022	11021	+34
68-	+	3411027	11028							
69-	CHEXA	2011	2	1024	1023	1029	1030	11024	11023	+35
70-	+	3511029	11030							
71-	CHEXA	2012	2	1025	1024	1030	1031	11025	11024	+36
72-	+	3611030	11031							
73-	CHEXA	2013	2	1026	1025	1031	1032	11026	11025	+37
74-	+	3711031	11032							
75-	CHEXA	2014	2	1027	1026	1032	1033	11027	11026	+38
76-	+	3811032	11033							
77-	CHEXA	2015	2	1028	1027	1033	1034	11028	11027	+39
78-	+	3911033	11034							
79-	CHEXA	2016	2	1030	1029	1035	1036	11030	11029	+40
80-	+	4011035	11036							
81-	CHEXA	2017	2	1031	1030	1036	1037	11031	11030	+41
82-	+	4111036	11037							
83-	CHEXA	2018	2	1032	1031	1037	1038	11032	11031	+42
84-	+	4211037	11038							
85-	CHEXA	2019	2	1033	1032	1038	1039	11033	11032	+43
86-	+	4311038	11039							
87-	CHEXA	2020	2	1034	1033	1039	1040	11034	11033	+44
88-	+	4411039	11040							
89-	CHEXA	2021	2	1036	1035	1041	1042	11036	11035	+45
90-	+	4511041	11042							
91-	CHEXA	2022	2	1037	1036	1042	1043	11037	11036	+46
92-	+	4611042	11043							
93-	CHEXA	2023	2	1038	1037	1043	1044	11038	11037	+47
94-	+	4711043	11044							
95-	CHEXA	2024	2	1039	1038	1044	1045	11039	11038	+48
96-	+	4811044	11045							
97-	CHEXA	2025	2	1040	1039	1045	1046	11040	11039	+49
98-	+	4911045	11046							
99-	CHEXA	2026	2	1042	1041	1047	1048	11042	11041	+50
100-	+	5011047	11048							

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	1	2	3	4	5	6	7	8	9	10
101-	CHEXA	2027	2	1043	1042	1048	1049	11043	11042	+ 51
102-	+	5111048	11049							
103-	CHEXA	2028	2	1044	1043	1049	1050	11044	11043	+ 52
104-	+	5211049	11050							
105-	CHEXA	2029	2	1045	1044	1050	1051	11045	11044	+ 53
106-	+	5311050	11051							
107-	CHEXA	2030	2	1046	1045	1051	1052	11046	11045	+ 54
108-	+	5411051	11052							
109-	CHEXA	3001	3	1048	1047	1053	1054	11048	11047	+ 55
110-	+	5511053	11054							
111-	CHEXA	3002	3	1049	1048	1054	1055	11049	11048	+ 56
112-	+	5611054	11055							
113-	CHEXA	3003	3	1050	1049	1055	1056	11050	11049	+ 57
114-	+	5711055	11056							
115-	CHEXA	3004	3	1051	1050	1056	1057	11051	11050	+ 58
116-	+	5811056	11057							
117-	CHEXA	3005	3	1052	1051	1057	1058	11052	11051	+ 59
118-	+	5911057	11058							
119-	CHEXA	3006	3	1054	1053	1059	1060	11054	11053	+ 60
120-	+	6011059	11060							
121-	CHEXA	3007	3	1055	1054	1060	1061	11055	11054	+ 61
122-	+	6111060	11061							
123-	CHEXA	3008	3	1056	1055	1061	1062	11056	11055	+ 62
124-	+	6211061	11062							
125-	CHEXA	3009	3	1057	1056	1062	1063	11057	11056	+ 63
126-	+	6311062	11063							
127-	CHEXA	3010	3	1058	1057	1063	1064	11058	11057	+ 64
128-	+	6411063	11064							
129-	CHEXA	3011	3	1060	1059	1065	1066	11060	11059	+ 65
130-	+	6511065	11066							
131-	CHEXA	3012	3	1061	1060	1066	1067	11061	11060	+ 66
132-	+	6611066	11067							
133-	CHEXA	3013	3	1062	1061	1067	1068	11062	11061	+ 67
134-	+	6711067	11068							
135-	CHEXA	3014	3	1063	1062	1068	1069	11063	11062	+ 68
136-	+	6811068	11069							
137-	CHEXA	3015	3	1064	1063	1069	1070	11064	11063	+ 69
138-	+	6911069	11070							
139-	CORD2C	100		.6700	.5100	.0	.6700	.5100	1.0	+ 24
140-	+	241.6700	.5100	.0						
141-	CORD2R	50		.0	.76	0.0	.0	.76	.1	+CORD2R
142-	+CORD2R	.0	.5	0.0						
143-	CPENTA	1007	1	1004	1008	1009	11004	11008	11009	
144-	FORCE	1	1065	0	-2.5	.0	1.0	.0		
145-	FORCE	1	1066	0	-5.0	.0	1.0	.0		
146-	FORCE	1	1067	0	-5.0	.0	1.0	.0		
147-	FORCE	1	1068	0	-5.0	.0	1.0	.0		
148-	FORCE	1	1069	0	-5.0	.0	1.0	.0		
149-	FORCE	1	1070	0	-2.50	.0	1.0	.0		
150-	FORCE	2	11065	0	-2.50	.0	1.0	.0		

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
151-	FORCE	2	11066	0	-5.0	.0	1.0	.0		
152-	FORCE	2	11067	0	-5.0	.0	1.0	.0		
153-	FORCE	2	11068	0	-5.0	.0	1.0	.0		
154-	FORCE	2	11069	0	-5.0	.0	1.0	.0		
155-	FORCE	2	11070	0	-2.5	.0	1.0	.0		
156-	GRDSET							456		
157-	GRID	1		.4000	.6350	.5000				
158-	GRID	2		.4000	.6350	.4000				
159-	GRID	3		.4000	.6350	.3000				
160-	GRID	4		.4000	.6350	.2500				
161-	GRID	5		.2667	.6350	.5000				
162-	GRID	6		.2667	.6350	.4000				
163-	GRID	7		.2667	.6350	.3000				
164-	GRID	8		.2667	.6350	.2115				
165-	GRID	9		.1334	.6350	.5000				
166-	GRID	10		.1334	.6350	.4000				
167-	GRID	11		.1334	.6350	.3000				
168-	GRID	12		.1334	.6350	.2000				
169-	GRID	13		.1334	.6350	.1000				
170-	GRID	14		.1709	.6350	.1000				
171-	GRID	15		.1334	.6350	.0				
172-	GRID	16		.1500	.6350	.0				
173-	GRID	17		.0	.6350	.5000				
174-	GRID	18		.0	.6350	.4000				
175-	GRID	19		.0	.6350	.3000				
176-	GRID	20		.0	.6350	.2000				
177-	GRID	21		.0	.6350	.1000				
178-	GRID	22		.0	.6350	.0				
179-	GRID	1001		.4900	.6350	.5000				
180-	GRID	1002		.4900	.6350	.4000				
181-	GRID	1003		.4900	.6350	.3000				
182-	GRID	1004		.4900	.6350	.2332				
183-	GRID	1005		.5800	.6350	.5000				
184-	GRID	1006		.5800	.6350	.4000				
185-	GRID	1007		.5800	.6350	.3000				
186-	GRID	1008		.5800	.6350	.2000				
187-	GRID	1009		.6251	.6350	.1000				
188-	GRID	1010		.6700	.6350	.5000				
189-	GRID	1011		.6700	.6350	.4000				
190-	GRID	1012		.6700	.6350	.3000				
191-	GRID	1013		.6700	.6350	.2000				
192-	GRID	1014		.6700	.6350	.1000				
193-	GRID	1015		.6700	.6350	.0				
194-	GRID	1016		.6500	.6350	.0				
195-	GRID	1017	100	.1250	75.0000	.5000				
196-	GRID	1018	100	.1250	75.0000	.4000				
197-	GRID	1019	100	.1250	75.0000	.3000				
198-	GRID	1020	100	.1250	75.0000	.2000				
199-	GRID	1021	100	.1250	75.0000	.1000				
200-	GRID	1022	100	.1250	75.0000	.0				

12
B

COMPOSIT BRACKET MODEL C18 (PHASE 2)
MAT9 PO52 (0(13)/45(12)), DR =.125, T =.125

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
201-	GRID	1023	100	.1250	60.0000	.5000				
202-	GRID	1024	100	.1250	60.0000	.4000				
203-	GRID	1025	100	.1250	60.0000	.3000				
204-	GRID	1026	100	.1250	60.0000	.2000				
205-	GRID	1027	100	.1250	60.0000	.1000				
206-	GRID	1028	100	.1250	60.0000	.0				
207-	GRID	1029	100	.1250	45.0000	.5000				
208-	GRID	1030	100	.1250	45.0000	.4000				
209-	GRID	1031	100	.1250	45.0000	.3000				
210-	GRID	1032	100	.1250	45.0000	.2000				
211-	GRID	1033	100	.1250	45.0000	.1000				
212-	GRID	1034	100	.1250	45.0000	.0				
213-	GRID	1035	100	.1250	30.0000	.5000				
214-	GRID	1036	100	.1250	30.0000	.4000				
215-	GRID	1037	100	.1250	30.0000	.3000				
216-	GRID	1038	100	.1250	30.0000	.2000				
217-	GRID	1039	100	.1250	30.0000	.1000				
218-	GRID	1040	100	.1250	30.0000	.0				
219-	GRID	1041	100	.1250	15.0000	.5000				
220-	GRID	1042	100	.1250	15.0000	.4000				
221-	GRID	1043	100	.1250	15.0000	.3000				
222-	GRID	1044	100	.1250	15.0000	.2000				
223-	GRID	1045	100	.1250	15.0000	.1000				
224-	GRID	1046	100	.1250	15.0000	.0				
225-	GRID	1047	100	.1250	.0	.5000				
226-	GRID	1048	100	.1250	.0	.4000				
227-	GRID	1049	100	.1250	.0	.3000				
228-	GRID	1050	100	.1250	.0	.2000				
229-	GRID	1051	100	.1250	.0	.1000				
230-	GRID	1052	100	.1250	.0	.0				
231-	GRID	1053		.7950	.3400	.5000				
232-	GRID	1054		.7950	.3400	.4000				
233-	GRID	1055		.7950	.3400	.3000				
234-	GRID	1056		.7950	.3400	.2000				
235-	GRID	1057		.7950	.3400	.1000				
236-	GRID	1058		.7950	.3400	.0				
237-	GRID	1059		.7950	.1700	.5000				
238-	GRID	1060		.7950	.1700	.4000				
239-	GRID	1061		.7950	.1700	.3000				
240-	GRID	1062		.7950	.1700	.2000				
241-	GRID	1063		.7950	.1700	.1000				
242-	GRID	1064		.7950	.1700	.0				
243-	GRID	1065		.7950	.0	.5000				
244-	GRID	1066		.7950	.0	.4000				
245-	GRID	1067		.7950	.0	.3000				
246-	GRID	1068		.7950	.0	.2000				
247-	GRID	1069		.7950	.0	.1000				
248-	GRID	1070		.7950	.0	.0				
249-	GRID	10001		.4000	.7600	.5000				
250-	GRID	10002		.4000	.7600	.4000				

COMPOSIT BRACKET MODEL C18 (PHASE 2) SEPTEMBER 7, 1978 NASTRAN 3/11/78
PAT9 M052 (0(13)/45(12)), DR =.125, T =.125

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
251-	GRID	10003		.4000	.7600	.3000				
252-	GRID	10004		.4000	.7600	.2500				
253-	GRID	10005		.2667	.7600	.5000				
254-	GRID	10006		.2667	.7600	.4000				
255-	GRID	10007		.2667	.7600	.3000				
256-	GRID	10008		.2667	.7600	.2115				
257-	GRID	10009		.1334	.7600	.5000				
258-	GRID	10010		.1334	.7600	.4000				
259-	GRID	10011		.1334	.7600	.3000				
260-	GRID	10012		.1334	.7600	.2000				
261-	GRID	10013		.1334	.7600	.1000				
262-	GRID	10014		.1709	.7600	.1000				
263-	GRID	10015		.1334	.7600	.0				
264-	GRID	10016		.1500	.7600	.0				
265-	GRID	10017		.0	.7600	.5000				
266-	GRID	10018		.0	.7600	.4000				
267-	GRID	10019		.0	.7600	.3000				
268-	GRID	10020		.0	.7600	.2000				
269-	GRID	10021		.0	.7600	.1000				
270-	GRID	10022		.0	.7600	.0				
271-	GRID	11001		.4900	.7600	.5000				
272-	GRID	11002		.4900	.7600	.4000				
273-	GRID	11003		.4900	.7600	.3000				
274-	GRID	11004		.4900	.7600	.2332				
275-	GRID	11005		.5800	.7600	.5000				
276-	GRID	11006		.5800	.7600	.4000				
277-	GRID	11007		.5800	.7600	.3000				
278-	GRID	11008		.5600	.7600	.2000				
279-	GRID	11009		.6291	.7600	.1000				
280-	GRID	11010		.6700	.7600	.5000				
281-	GRID	11011		.6700	.7600	.4000				
282-	GRID	11012		.6700	.7600	.3000				
283-	GRID	11013		.6700	.7600	.2000				
284-	GRID	11014		.6700	.7600	.1000				
285-	GRID	11015		.6700	.7600	.0				
286-	GRID	11016		.6500	.7600	.0				
287-	GRID	11017	100	.2500	75.0000	.5000				
288-	GRID	11018	100	.2500	75.0000	.4000				
289-	GRID	11019	100	.2500	75.0000	.3000				
290-	GRID	11020	100	.2500	75.0000	.2000				
291-	GRID	11021	100	.2500	75.0000	.1000				
292-	GRID	11022	100	.2500	75.0000	.0				
293-	GRID	11023	100	.2500	60.0000	.5000				
294-	GRID	11024	100	.2500	60.0000	.4000				
295-	GRID	11025	100	.2500	60.0000	.3000				
296-	GRID	11026	100	.2500	60.0000	.2000				
297-	GRID	11027	100	.2500	60.0000	.1000				
298-	GRID	11028	100	.2500	60.0000	.0				
299-	GRID	11029	100	.2500	45.0000	.5000				
300-	GRID	11030	100	.2500	45.0000	.4000				

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
301-	GRID	11031	100	.2500	45.0000	.3000				
302-	GRID	11032	100	.2500	45.0000	.2000				
303-	GRID	11033	100	.2500	45.0000	.1000				
304-	GRID	11034	100	.2500	45.0000	.0				
305-	GRID	11035	100	.2500	30.0000	.5000				
306-	GRID	11036	100	.2500	30.0000	.4000				
307-	GRID	11037	100	.2500	30.0000	.3000				
308-	GRID	11038	100	.2500	30.0000	.2000				
309-	GRID	11039	100	.2500	30.0000	.1000				
310-	GRID	11040	100	.2500	30.0000	.0				
311-	GRID	11041	100	.2500	15.0000	.5000				
312-	GRID	11042	100	.2500	15.0000	.4000				
313-	GRID	11043	100	.2500	15.0000	.3000				
314-	GRID	11044	100	.2500	15.0000	.2000				
315-	GRID	11045	100	.2500	15.0000	.1000				
316-	GRID	11046	100	.2500	15.0000	.0				
317-	GRID	11047	100	.2500	.0	.5000				
318-	GRID	11048	100	.2500	.0	.4000				
319-	GRID	11049	100	.2500	.0	.3000				
320-	GRID	11050	100	.2500	.0	.2000				
321-	GRID	11051	100	.2500	.0	.1000				
322-	GRID	11052	100	.2500	.0	.0				
323-	GRID	11053		.9200	.3400	.5000				
324-	GRID	11054		.9200	.3400	.4000				
325-	GRID	11055		.9200	.3400	.3000				
326-	GRID	11056		.9200	.3400	.2000				
327-	GRID	11057		.9200	.3400	.1000				
328-	GRID	11058		.9200	.3400	.0				
329-	GRID	11059		.9200	.1700	.5000				
330-	GRID	11060		.9200	.1700	.4000				
331-	GRID	11061		.9200	.1700	.3000				
332-	GRID	11062		.9200	.1700	.2000				
333-	GRID	11063		.9200	.1700	.1000				
334-	GRID	11064		.9200	.1700	.0				
335-	GRID	11065		.9200	.0	.5000				
336-	GRID	11066		.9200	.0	.4000				
337-	GRID	11067		.9200	.0	.3000				
338-	GRID	11068		.9200	.0	.2000				
339-	GRID	11069		.9200	.0	.1000				
340-	GRID	11070		.9200	.0	.0				
341-	MAT9	100	1.792+6	4.682+5	4.558+5	.0	.0	.0	1.414+7	ELAS201
342-	+LAS201	2.794+6	.0	.0	.0	4.104+6	.0	.0	.0	ELAS202
343-	+LAS202	6.350+5	.0	.0	2.972+6	.0	6.160+5			
344-	PSOLID	1	100	50						
345-	PSOLID	2	100	100						
346-	PSOLID	3	100	0						
347-	SEQGP	1	43	2	46	3	30	4	28	
348-	SEQGP	5	42	6	41	7	26	8	24	
349-	SEQGP	9	37	10	38	11	22	12	17	
350-	SEQGP	13	11	14	5	15	7	16	3	

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
351-	SEQGP	17	31	18	32	14	19	20	15	
352-	SEQGP	21	12	22	8	1001	47	1002	45	
353-	SEQGP	1003	51	1004	53	1005	55	1006	57	
354-	SEQGP	1007	59	1008	61	1009	63	1010	67	
355-	SEQGP	1011	69	1012	71	1013	73	1014	75	
356-	SEQGP	1015	76	1016	64	1017	87	1018	88	
357-	SEQGP	1019	65	1020	83	1021	81	1022	79	
358-	SEQGP	1023	91	1024	94	1025	95	1026	97	
359-	SEQGP	1027	99	1028	100	1029	103	1030	105	
360-	SEQGP	1031	107	1032	109	1033	112	1034	111	
361-	SEQGP	1035	123	1036	126	1037	122	1038	119	
362-	SEQGP	1039	117	1040	115	1041	127	1042	129	
363-	SEQGP	1043	131	1044	133	1045	135	1046	136	
364-	SEQGP	1047	148	1048	147	1049	145	1050	143	
365-	SEQGP	1051	141	1052	139	1053	161	1054	164	
366-	SEQGP	1055	159	1056	158	1057	155	1058	152	
367-	SEQGP	1059	165	1060	169	1061	174	1062	180	
368-	SEQGP	1063	178	1064	151	1065	167	1066	170	
369-	SEQGP	1067	175	1068	179	1069	184	1070	1	
370-	SEQGP	10001	44	10002	45	10003	29	10004	27	
371-	SEQGP	10005	39	10006	40	10007	25	10008	23	
372-	SEQGP	10009	35	10010	36	10011	21	10012	18	
373-	SEQGP	10013	13	10014	6	10015	5	10016	4	
374-	SEQGP	10017	33	10018	34	10019	20	10020	16	
375-	SEQGP	10021	14	10022	10	11001	48	11002	50	
376-	SEQGP	11003	52	11004	54	11005	56	11006	58	
377-	SEQGP	11007	60	11008	62	11009	65	11010	68	
378-	SEQGP	11011	70	11012	72	11013	74	11014	77	
379-	SEQGP	11015	78	11016	66	11017	85	11018	90	
380-	SEQGP	11019	86	11020	84	11021	82	11022	80	
381-	SEQGP	11023	92	11024	93	11025	96	11026	98	
382-	SEQGP	11027	101	11028	102	11029	104	11030	106	
383-	SEQGP	11031	108	11032	110	11033	113	11034	114	
384-	SEQGP	11035	124	11036	125	11037	121	11038	120	
385-	SEQGP	11039	118	11040	116	11041	128	11042	130	
386-	SEQGP	11043	132	11044	134	11045	137	11046	138	
387-	SEQGP	11047	149	11048	150	11049	146	11050	144	
388-	SEQGP	11051	142	11052	140	11053	162	11054	163	
389-	SEQGP	11055	160	11056	157	11057	156	11058	153	
390-	SEQGP	11059	166	11060	171	11061	173	11062	181	
391-	SEQGP	11063	177	11064	154	11065	168	11066	172	
392-	SEQGP	11067	176	11068	182	11069	183	11070	2	
393-	SPC1	9	2	10017	THRU	10022				
394-	SPC1	9	3	15	22					
395-	SPC1	9	3	1015	1022	1028	1034	1040	1046	
396-	SPC1	9	3	1052	1058	1064	1070			
397-	SPC1	9	3	10015	10022					
398-	SPC1	9	3	11015	11022	11028	11034	11040	11046	
399-	SPC1	9	3	11052	11058	11064	11070			
400-	SPC1	9	123	4	8	14	16			

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
401-	SPC1	9	123	1004	1009	1016				
402-	SPC1	9	123	10004	10006	10014	10016			
403-	SPC1	9	123	11004	11009	11016				
	ENDDATA									

TOTAL COUNT= 403

COMPOSITE BRACKET MODEL (10 (PHASE 2)   SEPTEMBER 7, 1978   NASTRAN 3/11/78
MAT9 MC52 (0(13)/45(12)), BR =.125, T =.125

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
NO.
  1  BEGIN    NO. 24 LINEAR STATIC ANALYSIS 7 JUN 1976 $
  2  PARAM    //DIAGON//47 $
  3  FILE     GM=SAVE / KNN=SAVE / MNN=SAVE $
  4  FILE     QG=APPEND/PGG=APPEND/UGV=APPEND $
  5  SETVAL   //V,N,CARDNO/0 $
  6  SETVAL   //V,N,PMDS/1/V,N,NOMOD/-1 $
  7  SETVAL   //V,N,NOKGGX/1 $
  8  SETVAL   //V,N,NOMGGX/1 $
  9  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/S,N,LUSET/C/S,N,
              NOGPDT $
 10  COND     RFERR,NOGPDT $
 11  GP2      GEOM2,EQEXIN/ECT $
 12  PARAML   PCDB//PRES////V,N,JUMPPLOT $
 13  COND     P1,JUMPPLOT $
 14  PARAM    //DIAGOFF//47 $
 15  PLTHBDY  GEOM2,ECT,EPT,SIL,EQEXIN,BGPDT/PECT,PSIL,PEQIN,PBGPDT/S,N,
              NHBDY/C,Y,MESH=NO $
 16  EQUIV    EQEXIN,PEQIN/NHBDY/ECT,PECT/NHBDY/BGPDT,PBGPDT/NHBDY/ SIL,PSIL/
              NHBDY $
 17  PLTSET   PCDB,PEQIN,PECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,NSIL/   S,N,
              JUMPPLOT $
 18  CHKPNT   PLTPAR,GPSETS,ELSETS $
 19  PRTMSG   PLTSETX// $
 20  SETVAL   //V,N,PLTFLG/1 / V,N,PFILE/0 $
 21  COND     P1,JUMPPLOT $
 22  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,PBGPDT,PEQIN,PSIL,,ECT,,/PLOTX1/
              NSIL/LUSET/S,N,JUMPPLOT/S,N,PLTFLG/S,N,PFILE $
 23  PRTMSG   PLOTX1//$
 24  LABEL    P1 $
 25  PARAM    //DIAGON//47 $
 26  GP3      GEOM3,EQEXIN,GEOM2/SLT,ETT/0/V,N,NOGRAV/0 $
 27  COND     LMODS,MODS $
 28  TA1,     ,ECT,EPT,BGPDT,SIL,ETT,CSTM/EST,,GEI,GPECT,/V,N,LUSET/0/   S,N,
              NOSIMP/1/S,N,NOGENL/S,N,GENEL $
 29  COND     LSKPEMG,NOSIMP $
 30  PARAM    //DIAGOFF//47 $
 31  EMG      EST,CSTM,MPT,DIT,GEOM2,,,/KELM,KDICT,MELM,MDICT,,/S,N,NOKGGX/
              S,N,NOMGGX/0///C,Y,COUPMASS $
 32  CHKPNT   KELM,KDICT $
 33  CHKPNT   MELM,MDICT $
 34  PARAM    //DIAGON//47 $
 35  PURGE    KGGX/NOKGGX $
 36  COND     LEMAK,NOKGGX $
 37  EMA      GPECT,KDICT,KELM,BGPDT,SIL,CSTM/KGGX, $
 38  LABEL    LEMAK $
 39  PURGE    MGGX/NOMGGX $
 40  COND     LMODS,NOMGGX $
 41  EMA      GPECT,MDICT,MELM,BGPDT,SIL,CSTM/MGGX,/-1/C,Y,WTMASS=1. $
 42  LABEL    LMODS $
```

COMPOSITE BRACKET MODEL (10 (PHASE 2)   SEPTEMBER 7, 1978   NASTRAN 3/11/78
MAT9 MC52 (0(13)/45(12)), BR =.125, T =.125

S DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	
501=	1049-4	1049-5	1049-6	11049-4	11049-5	11049-6	1048-4	1048-5	1048-6	1047-4 =	510
511=	1047-5	1047-6	11047-4	11047-5	11047-6	11048-4	11048-5	11048-6	1064-3	1064-4 =	520
521=	1064-5	1064-6	1058-3	1058-4	1058-5	1058-6	11058-3	11058-4	11058-5	11058-6 =	530
531=	11064-3	11064-4	11064-5	11064-6	1057-4	1057-5	1057-6	11057-4	11057-5	11057-6 =	540
541=	11056-4	11056-5	11056-6	1056-4	1056-5	1056-6	1055-4	1055-5	1055-6	11055-4 =	550
551=	11055-5	11055-6	1053-4	1053-5	1053-6	11053-4	11053-5	1105 -6	11054-4	11054-5 =	560
561=	11054-6	1054-4	1054-5	1054-6	1059-4	1059-5	1059-6	11059-4	11059-5	11059-6 =	570
571=	1065-4	1065-5	1065-6	11065-4	11065-5	11065-6	1060-4	1060-5	1060-6	1066-4 =	580
581=	1066-5	1066-6	11060-4	11060-5	11060-6	11066-4	11066-5	11066-6	11061-4	11061-5 =	590
591=	11061-6	1061-4	1061-5	1061-6	1067-4	1067-5	1067-6	11067-4	11067-5	11067-6 =	600
601=	11063-4	11063-5	11063-6	1063-4	1063-5	1063-6	1068-4	1068-5	1068-6	1062-4 =	610
611=	1062-5	1062-6	11062-4	11062-5	11062-6	11068-4	11068-5	11068-6	11069-4	11069-5 =	620
621=	11069-6	1069-4	1069-5	1069-6							

*** USER INFORMATION MESSAGE 3035 FOR DATA BLOCK KLL

LOAD SEQ. NO.	EPSILON	STRAIN ENERGY
1	-6.2282216E-13	4.4432953E-03
2	-6.7232667E-13	8.4542669E-03

EPSILONS LARGER THAN.001 ARE FLAGGED WITH ASTERISKS

COMPOSIT BRACKET MODEL C18 (PHASE 2) SEPTEMBER 7, 1978 NASTRAN 3/11/78
UNIFORM FULL

SUBCOM 3

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-5.262619E-05	-1.922596E-05	1.375301E-05	0.0	0.0	0.0
2	G	-4.728325E-05	-2.212649E-05	3.446548E-07	0.0	0.0	0.0
3	G	-2.788696E-05	-6.166291E-06	-7.495612E-06	0.0	0.0	0.0
4	G	0.0	0.0	0.0	0.0	0.0	0.0
5	G	-2.866791E-05	2.213701E-05	9.615137E-06	0.0	0.0	0.0
6	G	-2.315911E-05	1.162473E-05	8.852112E-07	0.0	0.0	0.0
7	G	-1.203906E-05	6.729394E-06	-4.120740E-06	0.0	0.0	0.0
8	G	0.0	0.0	0.0	0.0	0.0	0.0
9	G	-1.526834E-05	2.016335E-05	3.064246E-06	0.0	0.0	0.0
10	G	-1.117698E-05	1.220341E-05	-4.039057E-07	0.0	0.0	0.0
11	G	-6.471892E-06	6.296521E-06	-2.158332E-06	0.0	0.0	0.0
12	G	-2.104930E-06	2.408457E-06	-1.792477E-06	0.0	0.0	0.0
13	G	1.342820E-07	1.371654E-08	1.218012E-08	0.0	0.0	0.0
14	G	0.0	0.0	0.0	0.0	0.0	0.0
15	G	1.418585E-08	-1.136030E-07	0.0	0.0	0.0	0.0
16	G	0.0	0.0	0.0	0.0	0.0	0.0
17	G	-1.099438E-05	1.477626E-05	-2.242820E-06	0.0	0.0	0.0
18	G	-7.896861E-06	8.516805E-06	-4.116370E-06	0.0	0.0	0.0
19	G	-4.914150E-06	4.808227E-06	-4.637925E-06	0.0	0.0	0.0
20	G	-2.257953E-06	2.017201E-06	-3.531409E-06	0.0	0.0	0.0
21	G	-5.222137E-07	3.533740E-07	-1.834125E-06	0.0	0.0	0.0
22	G	2.120210E-07	-4.025042E-07	0.0	0.0	0.0	0.0
1001	G	-7.493258E-05	-8.529247E-05	1.617774E-05	0.0	0.0	0.0
1002	G	-6.573025E-05	-8.092189E-05	-2.371153E-07	0.0	0.0	0.0
1003	G	-5.119233E-05	-4.038290E-05	-6.927859E-06	0.0	0.0	0.0
1004	G	0.0	0.0	0.0	0.0	0.0	0.0
1005	G	-9.913128E-05	-1.974152E-04	1.737924E-05	0.0	0.0	0.0
1006	G	-9.620441E-05	-1.873290E-04	7.909002E-07	0.0	0.0	0.0
1007	G	-7.956271E-05	-1.365205E-04	-5.489569E-06	0.0	0.0	0.0
1008	G	-3.852356E-05	-5.881613E-05	-5.643479E-06	0.0	0.0	0.0
1009	G	0.0	0.0	0.0	0.0	0.0	0.0
1010	G	-1.214356E-04	-3.539158E-04	1.605513E-05	0.0	0.0	0.0
1011	G	-1.220961E-04	-3.385078E-04	3.281252E-06	0.0	0.0	0.0
1012	G	-1.120896E-04	-2.893244E-04	-2.945315E-06	0.0	0.0	0.0
1013	G	-8.053301E-05	-2.110353E-04	-2.321525E-06	0.0	0.0	0.0
1014	G	-4.342220E-05	-1.083612E-04	1.521442E-06	0.0	0.0	0.0
1015	G	-2.098735E-05	-4.139509E-05	0.0	0.0	0.0	0.0
1016	G	0.0	0.0	0.0	0.0	0.0	0.0
1017	G	-1.394116E-04	-4.227664E-04	1.343862E-05	0.0	0.0	0.0
1018	G	-1.415894E-04	-4.046147E-04	2.935622E-06	0.0	0.0	0.0
1019	G	-1.350971E-04	-3.617792E-04	-1.519945E-06	0.0	0.0	0.0
1020	G	-1.167044E-04	-3.013732E-04	5.356760E-07	0.0	0.0	0.0
1021	G	-9.068997E-05	-2.364539E-04	1.953598E-06	0.0	0.0	0.0
1022	G	-7.886355E-05	-2.083195E-04	0.0	0.0	0.0	0.0
1023	G	-1.802627E-04	-5.033957E-04	8.967210E-06	0.0	0.0	0.0
1024	G	-1.861268E-04	-4.878377E-04	8.619836E-07	0.0	0.0	0.0
1025	G	-1.856797E-04	-4.576812E-04	-2.074052E-06	0.0	0.0	0.0
1026	G	-1.822292E-04	-4.214407E-04	-5.976770E-07	0.0	0.0	0.0
1027	G	-1.738631E-04	-3.887110E-04	7.217008E-07	0.0	0.0	0.0
1028	G	-1.705180E-04	-3.750655E-04	0.0	0.0	0.0	0.0

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
4	G	5.742667E+00	4.687903E-01	2.306632E+00	0.0	0.0	0.0
8	G	2.100968E+00	-4.125071E-01	7.308962E-01	0.0	0.0	0.0
14	G	1.017702E-01	-6.981138E-02	1.706380E-01	0.0	0.0	0.0
15	G	0.0	0.0	9.224264E-02	0.0	0.0	0.0
16	G	-1.050246E-01	-4.627373E-03	6.160161E-02	0.0	0.0	0.0
22	G	0.0	0.0	1.567157E-01	0.0	0.0	0.0
1004	G	2.526744E+01	4.894345E+00	6.530153E+00	0.0	0.0	0.0
1009	G	3.644696E+01	1.451339E+01	9.271972E+00	0.0	0.0	0.0
1015	G	0.0	0.0	1.767538E+00	0.0	0.0	0.0
1016	G	1.582889E+01	7.360415E+00	1.670514E+00	0.0	0.0	0.0
1022	G	0.0	0.0	1.158304E+00	0.0	0.0	0.0
1028	G	0.0	0.0	5.165370E-01	0.0	0.0	0.0
1034	G	0.0	0.0	2.308506E-01	0.0	0.0	0.0
1040	G	0.0	0.0	1.177553E-01	0.0	0.0	0.0
1046	G	0.0	0.0	8.609080E-02	0.0	0.0	0.0
1052	G	0.0	0.0	2.448168E-01	0.0	0.0	0.0
1058	G	0.0	0.0	5.762329E-01	0.0	0.0	0.0
1064	G	0.0	0.0	1.142333E+00	0.0	0.0	0.0
1070	G	0.0	0.0	8.530007E-01	0.0	0.0	0.0
10004	G	-3.237593E+00	4.919993E-01	-2.643841E+00	0.0	0.0	0.0
10008	G	-5.008877E-01	-3.947772E-01	-2.686415E-01	0.0	0.0	0.0
10014	G	-1.471238E-01	-8.755267E-02	3.649689E-01	0.0	0.0	0.0
10015	G	0.0	0.0	8.067507E-02	0.0	0.0	0.0
10016	G	-1.162912E-01	-5.067468E-03	1.118920E-01	0.0	0.0	0.0
10017	G	0.0	-6.682015E-01	0.0	0.0	0.0	0.0
10018	G	0.0	-9.827982E-01	0.0	0.0	0.0	0.0
10019	G	0.0	-5.783293E-01	0.0	0.0	0.0	0.0
10020	G	0.0	-2.918631E-01	0.0	0.0	0.0	0.0
10021	G	0.0	-1.018713E-01	0.0	0.0	0.0	0.0
10022	G	0.0	-1.731257E-02	1.829902E-01	0.0	0.0	0.0
11004	G	-2.128593E+01	5.062610E+00	-8.548333E+00	0.0	0.0	0.0
11009	G	-3.978900E+01	1.386680E+01	-1.290089E+01	0.0	0.0	0.0
11015	G	0.0	0.0	-2.347250E+00	0.0	0.0	0.0
11016	G	-2.030682E+01	6.996297E+00	-3.171234E+00	0.0	0.0	0.0
11022	G	0.0	0.0	-2.981956E+00	0.0	0.0	0.0
11028	G	0.0	0.0	-1.966708E+00	0.0	0.0	0.0
11034	G	0.0	0.0	-9.046702E-01	0.0	0.0	0.0
11040	G	0.0	0.0	-5.147505E-02	0.0	0.0	0.0
11046	G	0.0	0.0	4.753534E-01	0.0	0.0	0.0
11052	G	0.0	0.0	1.396664E+00	0.0	0.0	0.0
11058	G	0.0	0.0	2.027456E+00	0.0	0.0	0.0
11064	G	0.0	0.0	2.254618E+00	0.0	0.0	0.0
11070	G	0.0	0.0	1.361585E+00	0.0	0.0	0.0

COMPOSIT BRACKET MODEL CIE (PHASE 2) SEPTEMBER 7, 1978 NASTRAN 3/11/76
UNIFORM PULL

SUBCOM 3

S T R E S S E S   I N   H E X A H E D R O N   S O L I D   E L E M E N T S   (H E X A)

ELEMENT-ID	CORNER GRID-ID	------CENTER AND CORNER POINT STRESSES--------- NORMAL		SHEAR		PRINCIPAL		DIR. COSINES -A- -B- -C-	MEAN PRESSURE	OCTAHEDRAL SHEAR
1	0GRID CS 8 GP									
	CENTER	X	-3.729564E+00	XY	-1.286974E+02	A	8.075562E+01	LX 0.81 0.57-0.15	3.149220E+01	1.156990E+02
		Y	-9.755629E+01	YZ	1.148072E+01	B	-1.677152E+02	LY-0.57 0.82 0.00		
		Z	6.011216E+00	ZX	-9.139227E+00	C	4.462697E+00	LZ-0.17-0.02-0.99		
	6	X	-5.267610E+01	XY	-1.337735E+02	A	-4.468672E+01	LX 1.00 0.06-0.04	8.353362E+02	1.055267E+03
		Y	-2.311657E+03	YZ	1.233842E+02	B	-2.326721E+03	LY-0.06 1.00-0.05		
		Z	-1.414742E+02	ZX	4.307328E+00	C	-1.346010E+02	LZ-0.03-0.06-1.00		
	5	X	-5.746271E+01	XY	-1.236213E+02	A	-5.058034E+01	LX 1.00 0.05-0.03	8.306345E+02	1.046104E+03
		Y	-2.295666E+03	YZ	1.233842E+02	B	-2.305494E+03	LY-0.06 1.00-0.06		
		Z	-1.393750E+02	ZX	4.307328E+00	C	-1.324254E+02	LZ-0.03-0.06-1.00		
	1	X	-1.502338E+01	XY	-1.236213E+02	A	6.817595E+01	LX-0.36 0.06-0.93	7.099426E+02	1.039101E+03
		Y	-2.164031E+03	YZ	1.233842E+02	B	-2.178563E+03	LY 0.07 1.00 0.03		
		Z	5.002544E+01	ZX	-2.258588E+01	C	-1.942084E+01	LZ 0.93-0.05-0.36		
	2	X	-6.036137E+01	XY	-1.337735E+02	A	6.385063E+01	LX-0.36 0.06-0.93	7.195662E+02	1.046390E+03
		Y	-2.183666E+03	YZ	1.233842E+02	B	-2.190515E+03	LY 0.07 1.00 0.04		
		Z	4.532695E+01	ZX	-2.258588E+01	C	-2.403360E+01	LZ 0.93-0.05-0.37		
	10006	X	3.283058E+01	XY	-1.337735E+02	A	2.143880E+03	LX-0.06 1.00 0.02	-7.679768E+02	9.735761E+02
		Y	2.130341E+03	YZ	-1.004228E+02	B	2.429503E+01	LY 1.00 0.06-0.05		
		Z	1.407590E+02	ZX	4.307328E+00	C	1.357558E+02	LZ-0.05 0.02-1.00		
	10005	X	2.501704E+01	XY	-1.236213E+02	A	2.067772E+03	LX-0.06 1.00 0.02	-7.349592E+02	9.433630E+02
		Y	2.055074E+03	YZ	-1.004228E+02	B	1.748633E+01	LY 1.00 0.06-0.05		
		Z	1.247865E+02	ZX	4.307328E+00	C	1.196152E+02	LZ-0.05 0.02-1.00		
	10001	X	3.007526E+01	XY	-1.236213E+02	A	1.971551E+03	LX-0.06 0.43-0.90	-6.506546E+02	9.364065E+02
		Y	1.958757E+03	YZ	-1.004228E+02	B	-3.020206E+01	LY 1.00 0.07-0.04		
		Z	-1.946803E+01	ZX	-2.258588E+01	C	3.601610E+01	LZ-0.05 0.90 0.43		
	10002	X	2.776558E+01	XY	-1.337735E+02	A	2.045023E+03	LX-0.07 0.52-0.85	-6.843508E+02	9.625112E+02
		Y	2.031380E+03	YZ	-1.004228E+02	B	-2.871458E+01	LY 1.00 0.08-0.03		
		Z	-6.042813E+00	ZX	-2.258588E+01	C	3.674451E+01	LZ-0.05 0.85 0.52		
2	0GRID CS 8 GP									
	CENTER	X	-4.390604E+01	XY	-1.241565E+02	A	1.190588E+02	LX 0.67 0.60-0.44	6.961356E+00	1.144493E+02
		Y	-4.734119E+01	YZ	5.446746E+01	B	-1.587438E+02	LY-0.63 0.77 0.09		
		Z	2.145594E+01	ZX	-6.050757E+00	C	1.286073E+01	LZ-0.39-0.21-0.89		
	7	X	-3.725171E+01	XY	-1.145275E+02	A	2.932689E+01	LX-0.01 0.07-1.00	5.691978E+02	8.057896E+02
		Y	-1.542428E+03	YZ	4.971213E+02	B	-1.708265E+03	LY 0.30 0.95 0.06		
		Z	-1.274135E+02	ZX	3.550512E+01	C	-2.865591E+01	LZ 0.95-0.30-0.03		

COMPOSIT BRACKET MODEL C16 (PHASE 2) SEPTEMBER 7, 1976 NASTRAN 3/11/76
UNIFORM PULL

SUBCOM 3

S T R E S S E S   I N   H E X A H E D R O N   S O L I D   E L E M E N T S   (I H E X 1)

------CENTER AND CORNER POINT STRESSES---------

ELEMENT-ID	CORNER GRID-ID		NORMAL		SHEAR		PRINCIPAL	DIR. COSINES -A- -B- -C-	MEAN PRESSURE	OCTAHEDRAL SHEAR
	6	X	-3.072057E+01	XY	-1.337735E+02	A	-6.273738E+01	LX 1.00 0.00 0.04	9.315757E+02	1.138598E+03
		Y	-2.421493E+03	YZ	4.971213E+02	B	-2.540068E+03	LY-0.05 0.97-0.22		
		Z	-3.025142E+02	ZX	3.550912E+01	C	-1.919223E+02	LZ 0.05-0.22-0.97		
	2	X	-4.596347E+01	XY	-1.337735E+02	A	1.999321E+01	LX 0.78 0.05-0.62	8.561292E+02	1.131874E+03
		Y	-2.339235E+03	YZ	4.971213E+02	B	-2.454370E+03	LY-0.17 0.98-0.14		
		Z	-1.831855E+02	ZX	-4.761073E+01	C	-1.360109E+02	LZ-0.60-0.21-0.77		
	3	X	-1.926875E+01	XY	-1.145275E+02	A	1.766035E+02	LX-0.30 0.06-0.92	4.971765E+02	6.002551E+02
		Y	-1.461544E+03	YZ	4.971213E+02	B	-1.621550E+03	LY 0.29 0.95-0.06		
		Z	-1.032280E+01	ZX	-4.761073E+01	C	-4.658694E+01	LZ 0.88-0.29-0.38		
	10007	X	2.618423E+01	XY	-1.145275E+02	A	1.579429E+03	LX-0.08-0.55-0.83	-5.364358E+02	7.375190E+02
		Y	1.466520E+03	YZ	-3.881863E+02	B	9.790524E+00	LY 0.96 0.17-0.20		
		Z	1.166040E+02	ZX	3.550912E+01	C	2.008833E+01	LZ-0.26 0.82-0.52		
	10006	X	4.656682E+01	XY	-1.337735E+02	A	2.296701E+03	LX-0.06 1.00-0.06	-8.412468E+02	1.031033E+03
		Y	2.213610E+03	YZ	-3.881863E+02	B	3.747794E+01	LY 0.98 0.05-0.19		
		Z	2.633635E+02	ZX	3.550912E+01	C	1.895615E+02	LZ-0.19-0.07-0.98		
	10002	X	6.004906E+01	XY	-1.337735E+02	A	2.308815E+03	LX-0.05 0.93 0.37	-8.565527E+02	1.030502E+03
		Y	2.227552E+03	YZ	-3.881863E+02	B	2.505203E+01	LY 0.98 0.12-0.15		
		Z	2.820521E+02	ZX	-4.761073E+01	C	2.357512E+02	LZ-0.19 0.35-0.92		
	10003	X	3.289232E+01	XY	-1.145275E+02	A	1.588710E+03	LX-0.06 0.71 0.70	-5.483145E+02	7.382537E+02
		Y	1.478492E+03	YZ	-3.881863E+02	B	-6.737268E+01	LY 0.96 0.22-0.14		
		Z	1.335595E+02	ZX	-4.761073E+01	C	1.036026E+02	LZ-0.26 0.67-0.70		
3	SO+MAT CS 4 GP									
	CENTER	X	-1.392570E+01	XY	-5.951460E+01	A	1.630720E+02	LX-0.28-0.45-0.85	-1.890781E+01	9.849562E+01
		Y	5.523095E+01	YZ	9.930753E+01	B	-9.786690E+01	LY 0.80-0.60 0.06		
		Z	1.872133E+00	ZX	1.272573E+01	C	1.175837E+01	LZ 0.53 0.66-0.53		
	6	X	1.214119E+01	XY	8.986147E+00	A	1.503863E+03	LX 0.02-0.11-0.99	-3.684465E+02	8.238906E+02
		Y	1.105318E+03	YZ	7.778462E+02	B	-4.211137E+02	LY 0.89-0.45 0.07		
		Z	-1.811864E+01	ZX	5.023712E+01	C	1.661412E+01	LZ 0.46 0.89-0.09		
	7	X	-5.645866E+01	XY	-1.118807E+02	A	-8.517363E+01	LX 0.97 0.06 0.25	5.049925E+02	1.123589E+03
		Y	-1.988254E+03	YZ	9.646757E+02	B	-2.498208E+03	LY 0.07 0.88-0.46		
		Z	-6.460652E+02	ZX	7.508574E+01	C	-1.453968E+02	LZ 0.25-0.46-0.85		
	3	X	-1.110344E+02	XY	-1.280154E+02	A	-7.679019E+01	LX 0.94 0.04-0.33	1.014108E+03	1.128932E+03
		Y	-2.113409E+03	YZ	5.285849E+02	B	-2.602059E+03	LY-0.18 0.89-0.42		
		Z	-8.176794E+02	ZX	-3.278568E+01	C	-3.634773E+02	LZ-0.27-0.46-0.84		
	4	X	-7.385253E+00	XY	-7.148540E+00	A	1.337818E+03	LX-0.02 0.08-1.00	-2.594288E+02	7.488975E+02
		Y	9.786491E+02	YZ	7.672514E+02	B	-5.547180E+02	LY 0.90-0.43-0.05		
		Z	-1.912031E+02	ZX	-4.563824E+01	C	-4.815581E+00	LZ 0.44 0.90 0.08		

COMPOSIT BRACKET MODEL C16 (PHASE 2) SEPTEMBER 7, 1976 NASTRAN 3/11/76 PAGE [illegible]
COUPLE DUE TO ECCENTRICITY (CLOCKWISE)

SUBCOM 4

S T R E S S E S   I N   P E N T A H E D R O N   S O L I D   E L E M E N T S   (P E N T A)

------CENTER AND CORNER POINT STRESSES---------

ELEMENT-ID	CORNER GRID-ID		NORMAL		SHEAR		PRINCIPAL	DIR. COSINES -A- -B- -C-	MEAN PRESSURE	OCTAHEDRAL SHEAR
1007	SO+MAT CS 6 GP									
	CENTER	X	3.102488E+01	XY	-1.781555E+01	A	7.157778E+02	LX-0.02 0.94 0.33	-2.761189E+02	3.120190E+02
		Y	6.881411E+02	YZ	-1.331965E+02	B	2.374318E+01	LY 0.98 0.09-0.20		
		Z	1.111412E+02	ZX	-1.673008E+01	C	8.883640E+01	LZ-0.21 0.32-0.92		
	1004	X	-5.755995E+01	XY	-9.260282E+00	A	-5.716677E+01	LX 1.00 0.00 0.05	8.550288E+02	1.022817E+03
		Y	-2.223041E+03	YZ	3.906282E+02	B	-2.298848E+03	LY 0.01 0.98-0.19		
		Z	-2.844458E+02	ZX	9.915256E+00	C	-2.091135E+02	LZ 0.05-0.19-0.98		
	1008	X	-2.411890E+01	XY	-5.421777E+01	A	-5.486453E+00	LX 0.98 0.02-0.29	8.380885E+02	1.030944E+03
		Y	-2.214293E+03	YZ	3.506282E+02	B	-2.290898E+03	LY-0.07 0.98-0.18		
		Z	-2.758550E+02	ZX	-4.942786E+01	C	-2.178840E+02	LZ-0.28-0.19-0.94		
	1009	X	-5.755995E+01	XY	5.598316E+00	A	-5.705177E+01	LX 1.00-0.01-0.06	8.550288E+02	1.022827E+03
		Y	-2.223041E+03	YZ	3.906282E+02	B	-2.298855E+03	LY-0.01 0.98-0.19		
		Z	-2.844458E+02	ZX	-1.067543E+01	C	-2.051795E+02	LZ-0.06-0.19-0.98		
	11004	X	5.056673E+01	XY	-9.260282E+00	A	2.218010E+03	LX-0.01 1.00-0.05	-8.332231E+02	9.815156E+02
		Y	2.136358E+03	YZ	-3.951065E+02	B	5.816737E+01	LY 0.98-0.06-0.20		
		Z	3.047141E+02	ZX	9.915256E+00	C	2.234919E+02	LZ-0.20-0.05-0.98		
	11008	X	5.207779E+01	XY	-5.421777E+01	A	2.227565E+03	LX-0.02 0.94 0.34	-8.501628E+02	9.788813E+02
		Y	2.145106E+03	YZ	-3.951085E+02	B	6.948839E+01	LY 0.98 0.05-0.18		
		Z	3.133045E+02	ZX	-4.942786E+01	C	2.534391E+02	LZ-0.20 0.33-0.92		
	11009	X	5.056673E+01	XY	5.598316E+00	A	2.218020E+03	LX 0.01 1.00 0.05	-8.332231E+02	9.815259E+02
		Y	2.136358E+03	YZ	-3.951065E+02	B	5.805527E+01	LY 0.98 0.00-0.20		
		Z	3.047141E+02	ZX	-1.067543E+01	C	2.235505E+02	LZ-0.20 0.05-0.98		

COMPOSIT BRACKET MODEL C18 (PHASE 2)   SEPTEMBER 7, 1978   NASTRAN 3/11/78
UNIFORM PULL

SUBCOM 3

E L E M E N T   S T R A I N   E N E R G I E S

ELEMENT-TYPE = HEXA   * TOTAL ENERGY OF ALL ELEMENTS IN PROBLEM = 2.125516E-02
SUBCASE 3   TOTAL ENERGY OF ALL ELEMENTS IN SET -1 = 2.125516E-02

ELEMENT-ID	STRAIN-ENERGY	PERCENT OF TOTAL
1	1.247151E-04	0.5868
2	1.151692E-04	0.5418
3	6.280885E-05	0.2955
4	4.807640E-05	0.2262
5	3.058478E-05	0.1439
6	1.153078E-05	0.0542
7	8.188676E-07	0.0039
9	2.040611E-05	0.0960
10	8.905700E-06	0.0419
11	3.463125E-06	0.0163
12	1.176705E-06	0.0055
13	4.212168E-07	0.0020
1001	1.410414E-04	0.6636
1002	1.851362E-04	0.8710
1003	2.436545E-04	1.1463
1004	1.768684E-04	0.8321
1005	2.585645E-04	1.2165
1006	7.883434E-04	3.7090
1008	1.812274E-04	0.8526
1009	3.069104E-04	1.4439
1010	8.440975E-04	3.9713
1011	2.261107E-03	10.6379
1012	2.384876E-03	11.2202
2001	1.059914E-04	0.4987
2002	1.655374E-04	0.7788
2003	4.326985E-04	2.0357
2004	1.362822E-03	6.4117
2005	2.717839E-03	12.7867
2006	9.676283E-05	0.4552
2007	1.552182E-04	0.7303
2008	3.690170E-04	1.7361
2009	9.200568E-04	4.3284
2010	1.561032E-03	7.3442
2011	6.921771E-05	0.3257
2012	1.160833E-04	0.5461
2013	2.513996E-04	1.1828
2014	5.195271E-04	2.4442
2015	7.849804E-04	3.6931
2016	4.404518E-05	0.2072
2017	7.626465E-05	0.3588
2018	1.505644E-04	0.7084
2019	2.646290E-04	1.2450
2020	3.598982E-04	1.6932
2021	2.239327E-05	0.1054
2022	3.947558E-05	0.1857
2023	7.235016E-05	0.3404
2024	1.111822E-04	0.5231
2025	1.376617E-04	0.6477
2026	8.443447E-06	0.0397

G R I D P O I N T F O R C E B A L A N C E

POINT-ID	ELEMENT-ID	SOURCE	T1	T2	T3	R1	R2	R3
11062	3009	HEXA	6.999552E-02	2.266128E+00	-4.571041E-01	0.0	0.0	0.0
11062	3013	HEXA	-5.452161E-02	-2.307980E+00	4.245646E-01	0.0	0.0	0.0
11062	3014	HEXA	3.716827E-02	-2.565535E+00	-5.782720E-01	0.0	0.0	0.0
11062		*TOTALS*	4.382805E-14	-3.908084E-13	2.821354E-14	0.0	0.0	0.0
11063	3009	HEXA	-1.972941E-02	2.531496E+00	6.326695E-01	0.0	0.0	0.0
11063	3010	HEXA	4.421448E-02	2.447740E+00	-5.631822E-01	0.0	0.0	0.0
11063	3014	HEXA	-3.728447E-02	-2.445510E+00	5.720486E-01	0.0	0.0	0.0
11063	3015	HEXA	1.279940E-02	-2.533325E+00	-6.371360E-01	0.0	0.0	0.0
11063		*TOTALS*	5.430725E-14	-2.586620E-13	-8.125445E-14	0.0	0.0	0.0
11064		F-OF-SPC	0.0	0.0	-1.257136E+00	0.0	0.0	0.0
11064	3010	HEXA	1.296784E-02	2.498309E+00	6.183090E-01	0.0	0.0	0.0
11064	3015	HEXA	-1.296784E-02	-2.498309E+00	6.388301E-01	0.0	0.0	0.0
11064		*TOTALS*	5.186578E-14	-3.952714E-15	-1.633416E-14	0.0	0.0	0.0
11065		APP-LOAD	0.0	-2.499998E+00	0.0	0.0	0.0	0.0
11065	3011	HEXA	1.422473E-14	2.499958E+00	-4.440892E-15	0.0	0.0	0.0
11065		*TOTALS*	1.422473E-14	3.486100E-14	-4.440892E-15	0.0	0.0	0.0
11066		APP-LOAD	0.0	-4.999999E+00	0.0	0.0	0.0	0.0
11066	3011	HEXA	-5.621377E-02	2.575021E+00	1.179192E-01	0.0	0.0	0.0
11066	3012	HEXA	5.621377E-02	2.420978E+00	-1.179192E-01	0.0	0.0	0.0
11066		*TOTALS*	3.620875E-14	-5.198446E-14	-6.439294E-15	0.0	0.0	0.0
11067		APP-LOAD	0.0	-4.999999E+00	0.0	0.0	0.0	0.0
11067	3012	HEXA	-5.724376E-02	2.599545E+00	3.470544E-01	0.0	0.0	0.0
11067	3013	HEXA	5.724376E-02	2.400454E+00	-3.470544E-01	0.0	0.0	0.0
11067		*TOTALS*	4.678202E-14	7.428456E-14	2.444430E-14	0.0	0.0	0.0
11068		APP-LOAD	0.0	-4.999999E+00	0.0	0.0	0.0	0.0
11068	3013	HEXA	-4.233668E-02	2.568561E+00	5.448935E-01	0.0	0.0	0.0
11068	3014	HEXA	4.233668E-02	2.431037E+00	-5.448935E-01	0.0	0.0	0.0
11068		*TOTALS*	6.757619E-14	-1.487499E-14	1.101573E-14	0.0	0.0	0.0
11069		APP-LOAD	0.0	-4.999995E+00	0.0	0.0	0.0	0.0
11069	3014	HEXA	-2.214655E-02	2.528602E+00	6.667044E-01	0.0	0.0	0.0
11069	3015	HEXA	2.214659E-02	2.471337E+00	-6.667066E-01	0.0	0.0	0.0
11069		*TOTALS*	6.290570E-14	-4.884581E-14	2.430327E-14	0.0	0.0	0.0
11070		APP-LOAD	0.0	-2.499994E+00	0.0	0.0	0.0	0.0
11070		F-OF-SPC	0.0	0.0	-7.033048E-01	0.0	0.0	0.0

APPENDIX I

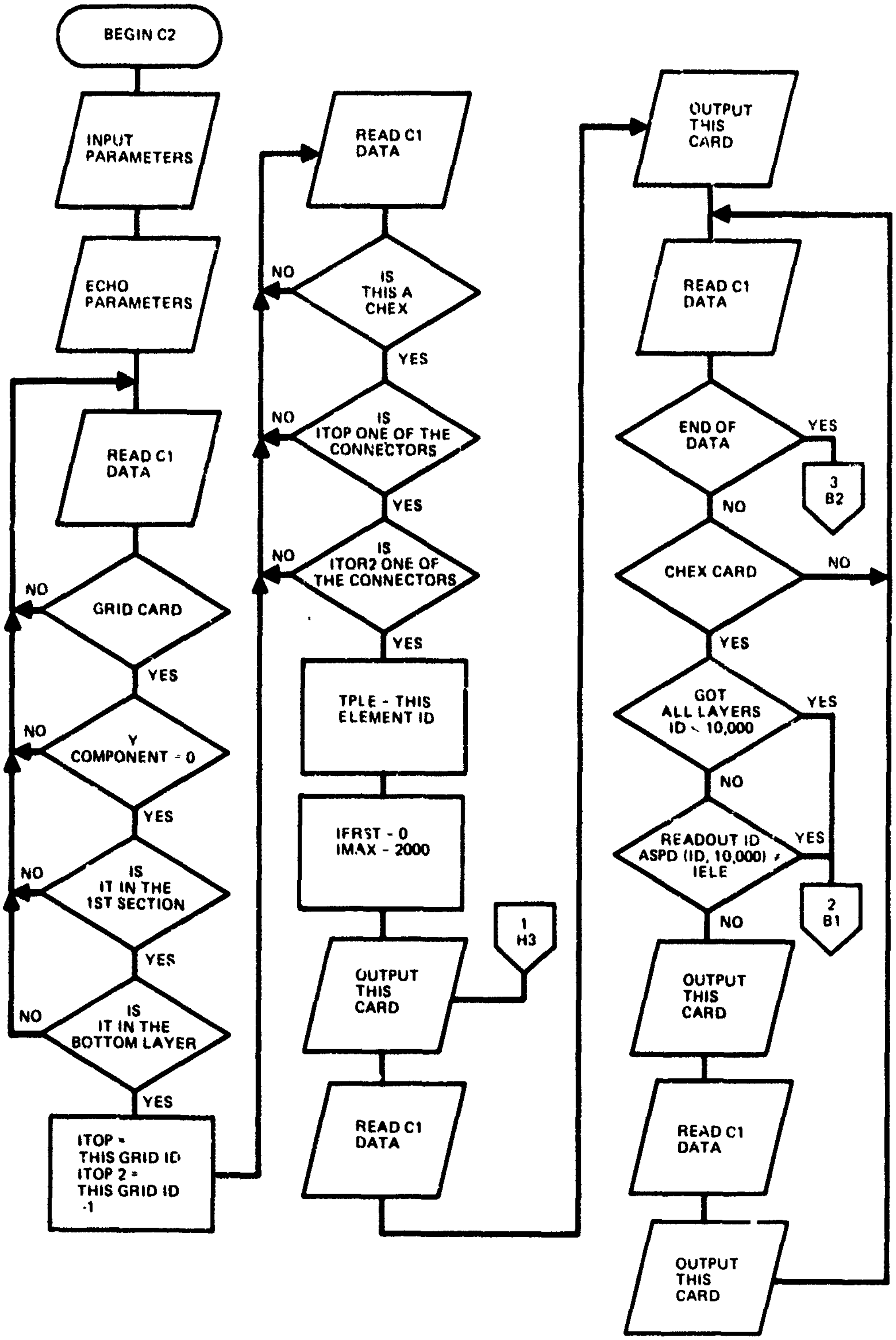
C-2 MODEL PREPROCESSOR PROGRAM LISTING

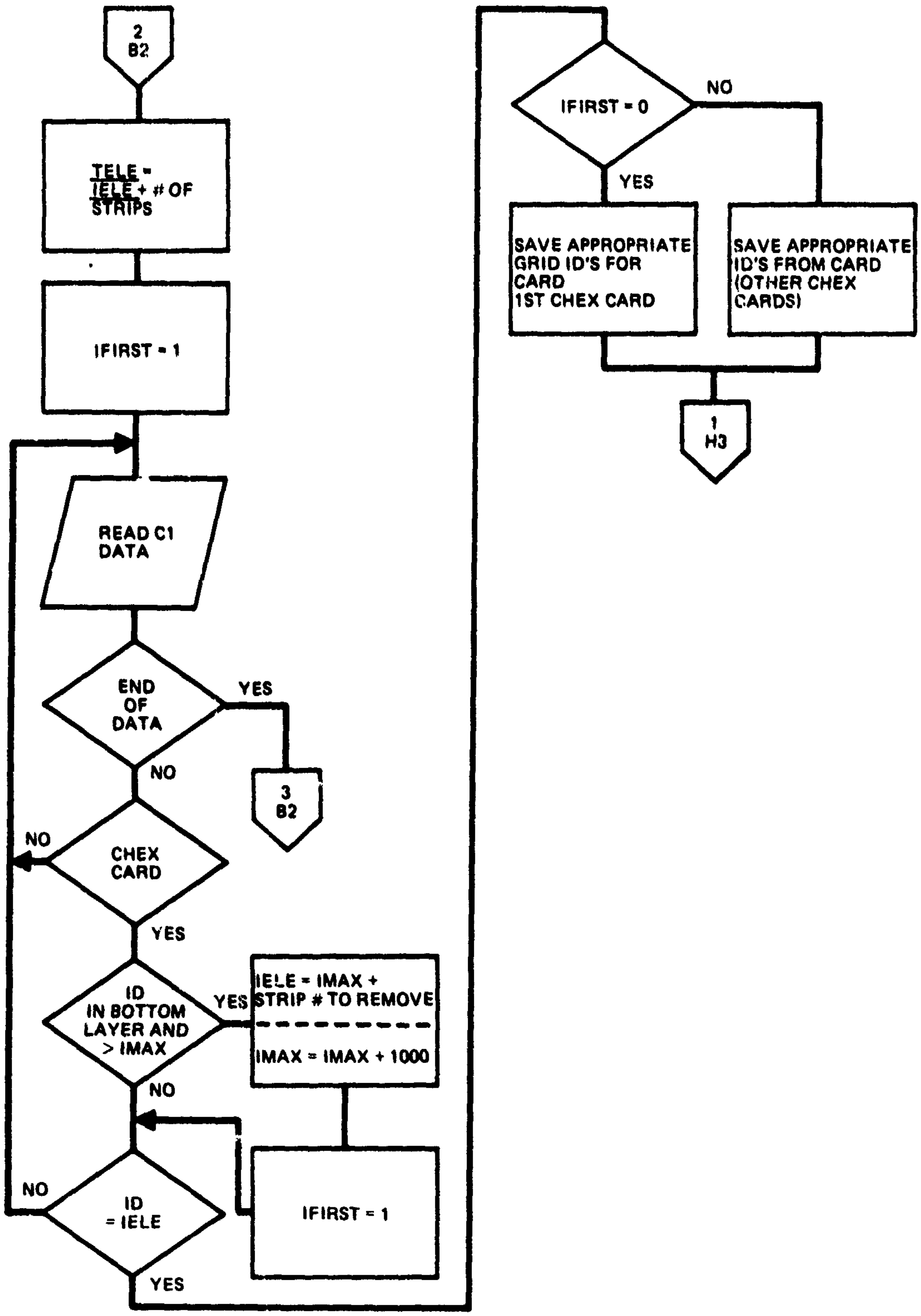
```
// JOB (CECEC6,,C4E),C22PREC2,CLASS=B
//STEP1 EXEC FORTHCLG,FC=190K
      DIMENSION ICARD(20),IGRID(2),IZERO(2),ICHEXA(2),IGRIDS(4000)
      INTEGER*2 NGRIDS,I1,I4
      DATA IGRID/'GRID','  '/,IZERO/'  0.','0'/,ICORD/'CORD'/,
     +ICHEXA/'CHEX','A'/,NGRIDS/4/,I1/1/,I4/4/
      EQUIVALENCE (IGRIDS(1),IG2),(IGRIDS(2),IG1),(IGRIDS(3),IG3),
     +(IGRIDS(4),IG4)
      READ(5,2)ISTRIP,ISTRPS
    2 FORMAT(2I3)
C
C     THIS PROGM IS FOR EXTRACTING BULK DATA FOR A PARTICULAR STRIP
C     FROM THE WHOLE BRACKET MULTILAYER BULK DATA, I.E. OBTAINING
C     C2 MODEL BULK DATA FROM PREPROCESSOR PRODUCED C1 BULK DECK
C
C     ECHO STRIP DATA
      WRITE(6,6) ISTRIP,ISTRPS
    6 FORMAT('1STRIP DATA ECHO',/,'0STRIP NO. = ',T20,I6,/,
     *' TOTAL STRIPS = ',T20,I6)
      IF(ISTRIP.LE.1.OR.ISTRIP.GT.ISTRPS)STOP 99
   10 READ(1,1)ICARD
    1 FORMAT(20A4)
      IF(ICARD(1).NE.IGRID(1).OR.ICARD(2).NE.IGRID(2))GO TO 10
      IF(ICARD(11).NE.IZERO(1).OR.ICARD(12).NE.IZERO(2))GO TO 10
      CALL CICON(ICARD(3),1,8,1,ITOP)
      IF(ITOP.LE.1000.OR.ITOP.GT.10000)GO TO 10
      ITOP2=ITOP-1
   20 READ(1,1)ICARD
      IF(ICARD(1).NE.ICHEXA(1).OR.ICARD(2).NE.ICHEXA(2))GO TO 20
      CALL CICON(ICARD(7),1,8,1,IG1)
      CALL CICON(ICARD(9),1,8,1,IG2)
      CALL CICON(ICARD(11),1,8,1,IG3)
      CALL CICON(ICARD(13),1,8,1,IG4)
      IF(ITOP.NE.IG1.AND.ITOP.NE.IG2.AND.ITOP.NE.IG3.AND.
     +ITOP.NE.IG4)GO TO 20
      IF(ITOP2.NE.IG1.AND.ITOP2.NE.IG2.AND.ITOP2.NE.IG3.AND.
     +ITOP2.NE.IG4)GO TO 20
      CALL CICON(ICARD(3),1,8,1,IELE)
      IFIRST=0
      IMAX=2000
   40 WRITE(2,1)ICARD
      READ(1,1)ICARD
      WRITE(2,1)ICARD
      DO 45 J=1,70
   46 READ(1,1,END=90)ICARD
      IF(ICARD(1).NE.ICHEXA(1).OR.ICARD(2).NE.ICHEXA(2))GO TO 46
      CALL CICON(ICARD(3),1,8,1,I)
      IF(I.LT.10000)GO TO 30
      IF(MOD(I,10000).NE.IELE)GO TO 30
      WRITE(2,1)ICARD
      READ(1,1)ICARD
      WRITE(2,1)ICARD
      GO TO 45
   45 CONTINUE
      STOP 999
   30 IELE=IELE+ISTRPS
      IFIRST=1
   35 READ(1,1,END=90)ICARD
```

```
      IF(ICARD(1).NE.ICHEXA(1).OR.ICARD(2).NE.ICHEXA(2))GO TO 35
      CALL CICON(ICARD(3),1,8,1,I)
      IF(I.GT.IMAX.AND.I.LT.10000)GO TO 50
   36 IF(I.NE.IELE)GO TO 35
      IF(IFIRST.NE.0)GO TO 37
      CALL CICON(ICARD(7),1,8,1,I)
      NGRIDS=NGRIDS+1
      IGRIDS(NGRIDS)=I
      CALL CICON(ICARD(13),1,8,1,I)
      NGRIDS=NGRIDS+1
      IGRIDS(NGRIDS)=I
      GO TO 40
   37 CALL CICON(ICARD(11),1,8,1,I)
      NGRIDS=NGRIDS+1
      IGRIDS(NGRIDS)=I
      CALL CICON(ICARD(13),1,8,1,I)
      NGRIDS=NGRIDS+1
      IGRIDS(NGRIDS)=I
      GO TO 40
   50 IELE=IMAX+ISTRIP
      IMAX=IMAX+1000
      IFIRST=1
      GO TO 36
   40 REWIND 1
      WRITE(6,3)NGRIDS,(IGRIDS(L),L=1,NGRIDS)
    3 FORMAT('1',I5,2X,(15I7,/))
      CALL ZSORTZ(IGRIDS,NGRIDS,I4,I1,I4)
      WRITE(6,3)NGRIDS,(IGRIDS(L),L=1,NGRIDS)
      DO 99 I=1,NGRIDS
      IF(I.NE.1)GO TO 94
   91 READ(1,1,END=93)ICARD
   94 IF(ICARD(1).EQ.ICORD)GO TO 60
      IF(ICARD(1).NE.IGRID(1).OR.ICARD(2).NE.IGRID(2))GO TO 91
      CALL CICON(ICARD(3),1,8,1,J)
      IF(J.NE.IGRIDS(I))GO TO 91
      WRITE(2,1)ICARD
      DO 92 J=1,70
      READ(1,1,END=93)ICARD
      IF(ICARD(1).NE.IGRID(1).OR.ICARD(2).NE.IGRID(2))GO TO 99
      CALL CICON(ICARD(3),1,8,1,K)
      IF(K.LT.10000)GO TO 99
      WRITE(2,1)ICARD
   92 CONTINUE
      STOP 999
   60 WRITE(2,1)ICARD
      READ(1,1)ICARD
      WRITE(2,1)ICARD
      GO TO 91
   99 CONTINUE
   93 ENDFILE 2
      STOP
      END
/*
//GO.FT01F001 DD DSN=CN0E0606.CVT.C22ELKPS,DISP=SHR
//GO.FT02F001 DD DSN=CNCE0606.CVT.C22BLKSS,UNIT=WYLBUR,DISP=(,CATLG),
//        SPACE=(TRK,(5,5),RLSE),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
//GO.SYSIN DD *
 3* 05
/*
```

APPENDIX J

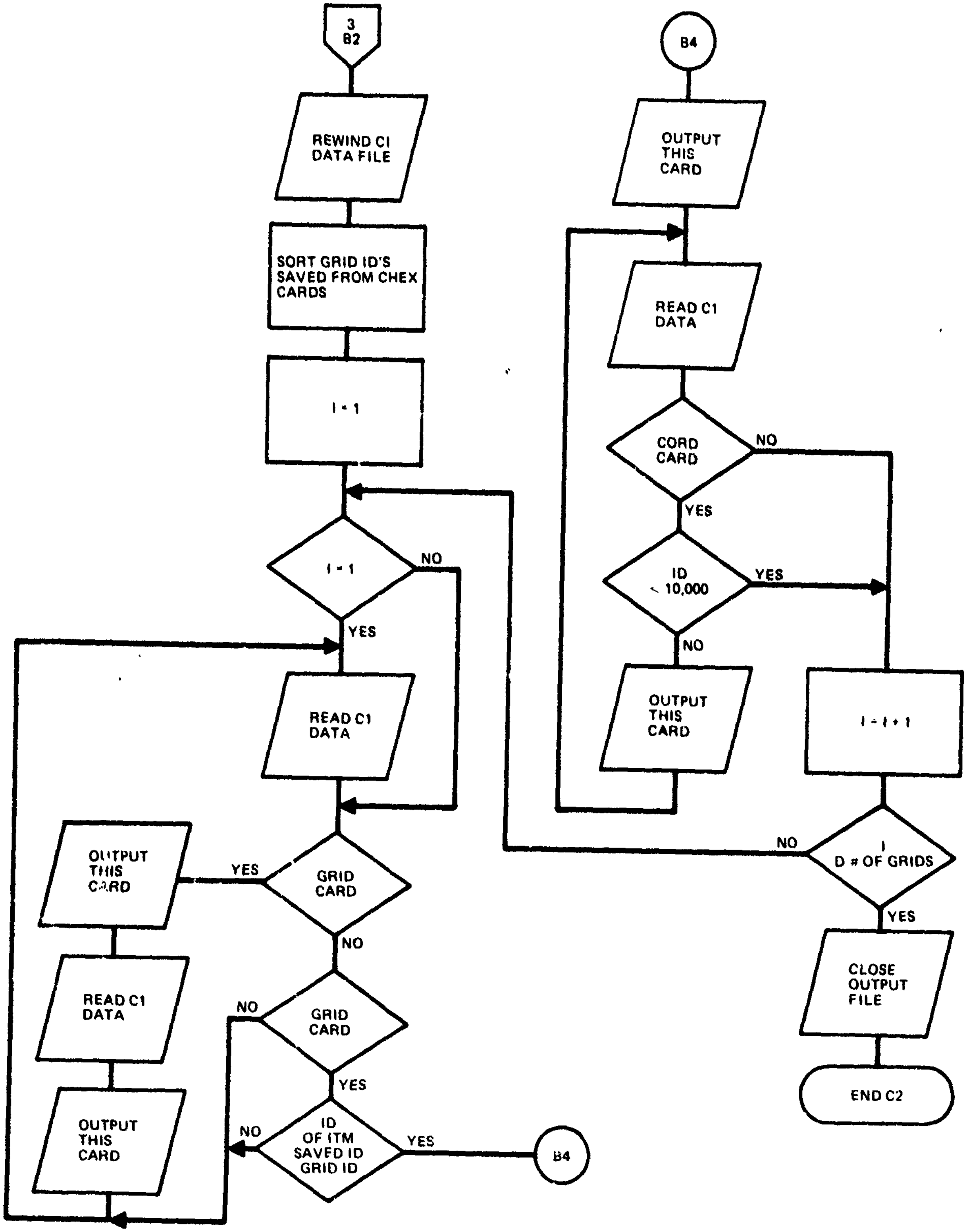
C-2 PREPROCESSOR FLOWCHART





2
B2
TELE =
IELE + # OF
STRIPS
IFIRST = 1
READ C1
DATA
END
OF
DATA
YES
3
B2
NO
CHEX
CARD
NO
YES
ID
IN BOTTOM
LAYER AND
> IMAX
YES
IELE = IMAX +
STRIP # TO REMOVE
IMAX = IMAX + 1000
NO
ID
= IELE
NO
IFIRST = 1
YES
IFIRST = 0
NO
YES
SAVE APPROPRIATE
GRID ID'S FOR
CARD
1ST CHEX CARD
SAVE APPROPRIATE
ID'S FROM CARD
(OTHER CHEX
CARDS)
1
H3

C-2 PREPROCESSOR



13
B

APPENDIX K

C-2 MODEL PREPROCESSOR PROGRAM OUTPUT

```
LEVEL 21.8 ( JUN 74 )                              OS/360  FORTRAN H

      COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=56,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,XREF
  ISN 0002        DIMENSION ICARD(20),IGRID(2),IZERO(2),ICHEXA(2),IGRIDS(4000)
  ISN 0003        INTEGER*2 NGRIDS,I1,I4
  ISN 0004        DATA IGRID/'GRID',' '/,IZERO/'  0.','0'/,ICORD/'CORD'/,
                 *ICHEXA/'CHEX','A'/,NGRIDS/4/,I1/1/,I4/4/
  ISN 0005        EQUIVALENCE (IGRIDS(1),IG2),(IGRIDS(2),IG1),(IGRIDS(3),IG3),
                 *(IGRIDS(4),IG4)
  ISN 0006        READ(5,2)ISTRIP,ISTRPS
  ISN 0007      2 FORMAT(2I5)
            C
            C     THIS PROGM IS FOR EXTRACTING BULK DATA FOR A PARTICULAR STRIP
            C     FROM THE WHOLE BRACKET MULTILAYER BULK DATA, I.E. OBTAINING
            C     C2 MODEL BULK DATA FROM PREPROCESSOR PRODUCED C1 BULK DECK
            C
            C     ECHO STRIP DATA
  ISN 0008        WRITE(6,6) ISTRIP,ISTRPS
  ISN 0009      6 FORMAT('1STRIP DATA ECHO',/,'0STRIP NO. = ',T20,I6,/,
                 *' TOTAL STRIPS = ',T20,I6)
  ISN 0010        IF(ISTRIP.LE.1.OR.ISTRIP.GT.ISTRPS)STOP 99
  ISN 0012     10 READ(1,1)ICARD
  ISN 0013      1 FORMAT(20A4)
  ISN 0014        IF(ICARD(1).NE.IGRID(1).OR.ICARD(2).NE.IGRID(2))GO TO 10
  ISN 0016        IF(ICARD(11).NE.IZERO(1).OR.ICARD(12).NE.IZERO(2))GO TO 10
  ISN 0018        CALL CICON(ICARD(3),1,8,1,ITOP)
  ISN 0019        IF(ITOP.LE.1000.OR.ITOP.GT.10000)GO TO 10
  ISN 0021        ITOP2=ITOP-1
  ISN 0022     20 READ(1,1)ICARD
  ISN 0023        IF(ICARD(1).NE.ICHEXA(1).OR.ICARD(2).NE.ICHEXA(2))GO TO 20
  ISN 0025        CALL CICON(ICARD(7),1,8,1,IG1)
  ISN 0026        CALL CICON(ICARD(9),1,8,1,IG2)
  ISN 0027        CALL CICON(ICARD(11),1,8,1,IG3)
  ISN 0028        CALL CICON(ICARD(13),1,8,1,IG4)
  ISN 0029        IF(ITOP.NE.IG1.AND.ITOP.NE.IG2.AND.ITOP.NE.IG3.AND.
                 *ITOP.NE.IG4)GO TO 20
  ISN 0031        IF(ITOP2.NE.IG1.AND.ITOP2.NE.IG2.AND.ITOP2.NE.IG3.AND.
                 *ITOP2.NE.IG4)GO TO 20
  ISN 0033        CALL CICON(ICARD(3),1,8,1,IELE)
  ISN 0034        IFIRST=0
  ISN 0035        IMAX=2000
  ISN 0036     40 WRITE(2,1)ICARD
  ISN 0037        READ(1,1)ICARD
  ISN 0038        WRITE(2,1)ICARD
  ISN 0039        DO 45 J=1,70
  ISN 0040     46 READ(1,1,END=90)ICARD
  ISN 0041        IF(ICARD(1).NE.ICHEXA(1).OR.ICARD(2).NE.ICHEXA(2))GO TO 46
  ISN 0043        CALL CICON(ICARD(3),1,8,1,I)
  ISN 0044        IF(I.LT.10000)GO TO 30
  ISN 0046        IF(MOD(I,10000).NE.IELE)GO TO 30
  ISN 0048        WRITE(2,1)ICARD
  ISN 0049        READ(1,1)ICARD
  ISN 0050        WRITE(2,1)ICARD
  ISN 0051        GO TO 45
  ISN 0052     45 CONTINUE
```

```
ISN 0053        STOP 999
ISN 0054    30  IELE=IELE+ISTRPS
ISN 0055        IFIRST=1
ISN 0056    35  READ(1,1,END=90)ICARD
ISN 0057        IF(ICARD(1).NE.IGHEXA(1).OR.ICARD(2).NE.IGHEXA(2))GO TO 35
ISN 0059        CALL CICON(ICARD(3),1,8,1,I)
ISN 0060        IF(I.GT.IMAX.AND.I.LT.10000)GO TO 50
ISN 0062    36  IF(I.NE.IELE)GO TO 35
ISN 0064        IF(IFIRST.NE.0)GO TO 37
ISN 0066        CALL CICON(ICARD(7),1,8,1,I)
ISN 0067        NGRIDS=NGRIDS+1
ISN 0068        IGRIDS(NGRIDS)=I
ISN 0069        CALL CICON(ICARD(13),1,8,1,I)
ISN 0070        NGRIDS=NGRIDS+1
ISN 0071        IGRIDS(NGRIDS)=I
ISN 0072        GO TO 40
ISN 0073    37  CALL CICON(ICARD(11),1,8,1,I)
ISN 0074        NGRIDS=NGRIDS+1
ISN 0075        IGRIDS(NGRIDS)=I
ISN 0076        CALL CICON(ICARD(13),1,8,1,I)
ISN 0077        NGRIDS=NGRIDS+1
ISN 0078        IGRIDS(NGRIDS)=I
ISN 0079        GO TO 40
ISN 0080    50  IELE=IMAX+ISTRIP
ISN 0081        IMAX=IMAX+1000
ISN 0082        IFIRST=1
ISN 0083        GO TO 36
ISN 0084    90  REWIND 1
ISN 0085        WRITE(6,3)NGRIDS,(IGRIDS(L),L=1,NGRIDS)
ISN 0086     3  FORMAT('1',I5,2X,(15I7,/))
ISN 0087        CALL ZSORT2(IGRIDS,NGRIDS,I4,I1,I4)
ISN 0088        WRITE(6,3)NGRIDS,(IGRIDS(L),L=1,NGRIDS)
ISN 0089        DO 99 I=1,NGRIDS
ISN 0090        IF(I.NE.1)GO TO 94
ISN 0092    91  READ(1,1,END=93)ICARD
ISN 0093    94  IF(ICARD(1).EQ.ICORD)GO TO 60
ISN 0095        IF(ICARD(1).NE.IGRID(1).OR.ICARD(2).NE.IGRID(2))GO TO 91
ISN 0097        CALL CICON(ICARD(3),1,8,1,J)
ISN 0098        IF(J.NE.IGRIDS(I))GO TO 91
ISN 0100        WRITE(2,1)ICARD
ISN 0101        DO 92 J=1,70
ISN 0102        READ(1,1,END=93)ICARD
ISN 0103        IF(ICARD(1).NE.IGRID(1).OR.ICARD(2).NE.IGRID(2))GO TO 99
ISN 0105        CALL CICON(ICARD(3),1,8,1,K)
ISN 0106        IF(K.LT.10000)GO TO 99
ISN 0108        WRITE(2,1)ICARD
ISN 0109    92  CONTINUE
ISN 0110        STOP 959
ISN 0111    60  WRITE(2,1)ICARD
ISN 0112        READ(1,1)ICARD
ISN 0113        WRITE(2,1)ICARD
ISN 0114        GO TO 91
ISN 0115    99  CONTINUE
ISN 0116    93  ENDFILE 2
```

```
ISN 0117          STOP
ISN 0118          END
```

```
STRIP DATA FORM

STRIP NO. =              5
TOTAL STRIPS =           5


20      1009    1010    1014    1015    1021    1022    1027    1028    1033    1034

1039    1040    1045    1046    1051    1052    1057    1056    1063    1064
```

APPENDIX L

C-2 PLOT RUN OUTPUT AND UNDEFORMED PLOTS

```
                                                                 OCTOBER  25, 1976   NASTRAN  3/11/76

 N A S T R A N    E X E C U T I V E    C O N T R O L    D E C K    E C H O


ID MODELC2,CRITSTRP
SOL 24
TIME 14
DIAG 8,14
ALTER 43 $
EXIT $
ENDALTER
CEND
                                                                 OCTOBER  25, 1976   NASTRAN  3/11/76
  MODEL C2.2 (PHASE 2) 13 LAYER CRITICAL STRIP
  C2-PRE-PROCESSOR PRODUCED BULK DATA

                              C A S E    C O N T R O L    D E C K    E C H O
              CARD
              COUNT
                1       TITLE = MODEL C2.. (PHASE 2) 13 LAYER CRITICAL STRIP
                2       SUBTITLE = C2-PRE-PROCESSOR PRODUCED BULK DATA
                3       OUTPUT(PLOT)
                4       PLOTTER NASTRAN MODEL D,0
                5       SET 3 = 1712 2009 THRU 2030 3105
                6       SET 4 = ALL
                7       $
                8       $ PLOT SIDE VIEW OF THE STRIP
                9       $
               10       AXES Z,X,Y
               11       VIEW 0.,0.,0.
               12       PTITLE=MESHES I,II, AND III - 0,0,0 VIEW
               13       FIND SCALE SET 4 ORIGIN 6
               14       PLOT SET 4 ORIGIN 6
               15       $
               16       $ PLOT MESHES I,II, AND III
               17       $
               18       AXES Z,X,Y
               19       VIEW -10.,20.,-30.
               20       PTITLE=MESHES I,II, AND III -10,20,-30 VIEW
               21       FIND SCALE SET 4 ORIGIN 5
               22       PLOT SET 4 ORIGIN 5
               23       $
               24       $ PLOT ONE LAYER OF THE STRIP
               25       $
               26       AXES Z,X,Y
               27       VIEW -10.,60.,-30.
               28       PTITLE = 3-D VIEW OF ONE LAYER OF THE STRIP
               29       FIND SCALE SET 3 ORIGIN 7
               30       PLOT SET 3 ORIGIN 7 LABEL ELEMENTS
               31       PLOT SET 3 ORIGIN 7 LABEL GRIDS
               32       $
               33       BEGIN BULK

                        TOTAL COUNT=  463

*** USER INFORMATION MESSAGE 207, BULK DATA NOT SORTED,XSORT WILL RE-ORDER DECK.
```

MODEL C?.. (PHASE 3) 13 LAYER CRITICAL STRIP OCTOBER 25, 1978 NASTRAN 3/11/78
C2-PRE-PROCESSOR PRODUCED BULK DATA

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
1-	CHEXA	1012	1	1016	1009	1014	1015	11016	11009	+ 299
2-	+ 299	11014	11015							
3-	CHEXA	2005	2	1015	1014	1021	1022	11015	11014	+ 365
4-	+ 365	11021	11022							
5-	CHEXA	2010	2	1022	1021	1027	1028	11022	11021	+ 430
6-	+ 430	11027	11028							
7-	CHEXA	2015	2	1028	1027	1033	1034	11028	11027	+ 495
8-	+ 495	11033	11034							
9-	CHEXA	2020	2	1034	1033	1039	1040	11034	11033	+ 560
10-	+ 560	11039	11040							
11-	CHEXA	2025	2	1040	1039	1045	1046	11040	11039	+ 625
12-	+ 625	11045	11046							
13-	CHEXA	2030	2	1046	1045	1051	1052	11046	11045	+ 690
14-	+ 690	11051	11052							
15-	CHEXA	3005	3	1052	1051	1057	1058	11052	11051	+ 755
16-	+ 755	11057	11058							
17-	CHEXA	11012	11	11016	11009	11014	11015	21016	21009	+ 300
18-	+ 300	21014	21015							
19-	CHEXA	12005	12	11015	11014	11021	11022	21015	21014	+ 366
20-	+ 366	21021	21022							
21-	CHEXA	12010	12	11022	11021	11027	11028	21022	21021	+ 431
22-	+ 431	21027	21028							
23-	CHEXA	12015	12	11028	11027	11033	11034	21028	21027	+ 496
24-	+ 496	21033	21034							
25-	CHEXA	12020	12	11034	11033	11039	11040	21034	21033	+ 561
26-	+ 561	21039	21040							
27-	CHEXA	12025	12	11040	11039	11045	11046	21040	21039	+ 626
28-	+ 626	21045	21046							
29-	CHEXA	12030	12	11046	11045	11051	11052	21046	21045	+ 691
30-	+ 691	21051	21052							
31-	CHEXA	13005	13	11052	11051	11057	11058	21052	21051	+ 756
32-	+ 756	21057	21058							
33-	CHEXA	21012	21	21016	21009	21014	21015	31016	31009	+ 301
34-	+ 301	31014	31015							
35-	CHEXA	22005	22	21015	21014	21021	21022	31015	31014	+ 367
36-	+ 367	31021	31022							
37-	CHEXA	22010	22	21022	21021	21027	21028	31022	31021	+ 432
38-	+ 432	31027	31028							
39-	CHEXA	22015	22	21028	21027	21033	21034	31028	31027	+ 497
40-	+ 497	31033	31034							
41-	CHEXA	22020	22	21034	21033	21039	21040	31034	31033	+ 562
42-	+ 562	31039	31040							
43-	CHEXA	22025	22	21040	21039	21045	21046	31040	31039	+ 627
44-	+ 627	31045	31046							
45-	CHEXA	22030	22	21046	21045	21051	21052	31046	31045	+ 692
46-	+ 692	31051	31052							
47-	CHEXA	23005	23	21052	21051	21057	21058	31052	31051	+ 757
48-	+ 757	31057	31058							
49-	CHEXA	31012	31	31016	31009	31014	31015	41016	41009	+ 302
50-	+ 302	41014	41015							

MODEL C2.2 (PHASE 2) [illegible]
C2-PRE-PROCESSOR PRODUCED [illegible] DATA

OCTOBER 25, 1978 NASTRAN 3/11/78

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
51-	CHEXA	32005	32	31015	31014	31021	31022	41015	41014	+308
52-	+308	41021	41022							
53-	CHEXA	32010	32	31022	31021	31027	31028	41022	41021	+433
54-	+433	41027	41028							
55-	CHEXA	32015	32	31028	31027	31033	31034	41028	41027	+498
56-	+498	41033	41034							
57-	CHEXA	32020	32	31034	31033	31039	31040	41034	41033	+563
58-	+563	41039	41040							
59-	CHEXA	32025	32	31040	31039	31045	31046	41040	41039	+628
60-	+628	41045	41046							
61-	CHEXA	32030	32	31046	31045	31051	31052	41046	41045	+693
62-	+693	41051	41052							
63-	CHEXA	33005	33	31052	31051	31057	31058	41052	41051	+758
64-	+758	41057	41058							
65-	CHEXA	41012	41	41016	41009	41014	41015	51016	51009	+303
66-	+303	51014	51015							
67-	CHEXA	42005	42	41015	41014	41021	41022	51015	51014	+369
68-	+369	51021	51022							
69-	CHEXA	42010	42	41022	41021	41027	41028	51022	51021	+434
70-	+434	51027	51028							
71-	CHEXA	42015	42	41028	41027	41033	41034	51028	51027	+499
72-	+499	51033	51034							
73-	CHEXA	42020	42	41034	41033	41039	41040	51034	51033	+564
74-	+564	51039	51040							
75-	CHEXA	42025	42	41040	41039	41045	41046	51040	51039	+629
76-	+629	51045	51046							
77-	CHEXA	42030	42	41046	41045	41051	41052	51046	51045	+694
78-	+694	51051	51052							
79-	CHEXA	43005	43	41052	41051	41057	41058	51052	51051	+759
80-	+759	51057	51058							
81-	CHEXA	51012	51	51016	51009	51014	51015	61016	61009	+304
82-	+304	61014	61015							
83-	CHEXA	52005	52	51015	51014	51021	51022	61015	61014	+370
84-	+370	61021	61022							
85-	CHEXA	52010	52	51022	51021	51027	51028	61022	61021	+435
86-	+435	61027	61028							
87-	CHEXA	52015	52	51028	51027	51033	51034	61028	61027	+500
88-	+500	61033	61034							
89-	CHEXA	52020	52	51034	51033	51039	51040	61034	61033	+565
90-	+565	61039	61040							
91-	CHEXA	52025	52	51040	51039	51045	51046	61040	61039	+630
92-	+630	61045	61046							
93-	CHEXA	52030	52	51046	51045	51051	51052	61046	61045	+695
94-	+695	61051	61052							
95-	CHEXA	53005	53	51052	51051	51057	51058	61052	61051	+760
96-	+760	61057	61058							
97-	CHEXA	61012	61	61016	61009	61014	61015	71016	71009	+305
98-	+305	71014	71015							
99-	CHEXA	62005	62	61015	61014	61021	61022	71015	71014	+371
100-	+371	71021	71022							

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
101-	CHEXA	62010	62	61022	61021	61027	61026	71022	71021	+ 436
102-	+	43671027	71028							
103-	CHEXA	62015	62	61028	61027	61033	61034	71028	71027	+ 501
104-	+	50171033	71034							
105-	CHEXA	62020	62	61034	61033	61039	61040	71034	71033	+ 566
106-	+	56671039	71040							
107-	CHEXA	62025	62	61040	61039	61045	61046	71040	71039	+ 631
108-	+	63171045	71046							
109-	CHEXA	62030	62	61046	61045	61051	61052	71046	71045	+ 696
110-	+	69671051	71052							
111-	CHEXA	63005	63	61052	61051	61057	61058	71052	71051	+ 761
112-	+	76171057	71058							
113-	CHEXA	71012	71	71016	71009	71014	71015	81016	81009	+ 306
114-	+	30681014	81015							
115-	CHEXA	72005	72	71015	71014	71021	71022	81015	81014	+ 372
116-	+	37281021	81022							
117-	CHEXA	72010	72	71022	71021	71027	71028	81022	81021	+ 437
118-	+	43781027	81028							
119-	CHEXA	72015	72	71028	71027	71033	71034	81028	81027	+ 502
120-	+	50281033	81034							
121-	CHEXA	72020	72	71034	71033	71039	71040	81034	81033	+ 567
122-	+	56781039	81040							
123-	CHEXA	72025	72	71040	71039	71045	71046	81040	81039	+ 632
124-	+	63281045	81046							
125-	CHEXA	72030	72	71046	71045	71051	71052	81046	81045	+ 697
126-	+	69781051	81052							
127-	CHEXA	73005	73	71052	71051	71057	71058	81052	81051	+ 762
128-	+	76281057	81058							
129-	CHEXA	81012	81	81016	81009	81014	81015	91016	91009	+ 307
130-	+	30791014	91015							
131-	CHEXA	82005	82	81015	81014	81021	81022	91015	91014	+ 373
132-	+	37391021	91022							
133-	CHEXA	82010	82	81022	81021	81027	81028	91022	91021	+ 438
134-	+	43891027	91028							
135-	CHEXA	82015	82	81028	81027	81033	81034	91028	91027	+ 503
136-	+	50391033	91034							
137-	CHEXA	82020	82	81034	81033	81039	81040	91034	91033	+ 568
138-	+	56891039	91040							
139-	CHEXA	82025	82	81040	81039	81045	81046	91040	91039	+ 633
140-	+	63391045	91046							
141-	CHEXA	82030	82	81046	81045	81051	81052	91046	91045	+ 698
142-	+	69891051	91052							
143-	CHEXA	83005	83	81052	81051	81057	81058	91052	91051	+ 763
144-	+	76391057	91058							
145-	CHEXA	91012	91	91016	91009	91014	91015	101016	101009	+ 308
146-	+	308101014	101015							
147-	CHEXA	92005	92	91015	91014	91021	91022	101015	101014	+ 374
148-	+	374101021	101022							
149-	CHEXA	92010	92	91022	91021	91027	91028	101022	101021	+ 439
150-	+	439101027	101028							

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
151-	CHEXA	92015	92	91026	91027	91033	91034	101028	101027	+ 504
152-	+	504101033	101034							
153-	CHEXA	92020	92	91034	91033	91039	91040	101034	101033	+ 569
154-	+	569101039	101040							
155-	CHEXA	92025	92	91040	91039	91045	91046	101040	101039	+ 634
156-	+	634101045	101046							
157-	CHEXA	92030	92	91046	91045	91051	91052	101046	101045	+ 699
158-	+	699101051	101052							
159-	CHEXA	93005	93	91052	91051	91057	91058	101052	101051	+ 764
160-	+	764101057	101058							
161-	CHEXA	101012	101	101016	101009	10101[illegible]	101015	111016	111009	+ 309
162-	+	309111014	111015							
163-	CHEXA	102005	102	101015	101014	101021	101022	111015	111014	+ 375
164-	+	375111021	111022							
165-	CHEXA	102010	102	101022	101021	101027	101028	111022	111021	+ 440
166-	+	440111027	111028							
167-	CHEXA	102015	102	101028	101027	101033	101034	111028	111027	+ 505
168-	+	505111033	111034							
169-	CHEXA	102020	102	101034	101033	101039	101040	111034	111033	+ 570
170-	+	570111039	111040							
171-	CHEXA	102025	102	101040	101039	101045	101046	111040	111039	+ 635
172-	+	635111045	111046							
173-	CHEXA	102030	102	101046	101045	101051	101052	111046	111045	+ 700
174-	+	700111051	111052							
175-	CHEXA	103005	103	101052	101051	101057	101058	111052	111051	+ 765
176-	+	765111057	111058							
177-	CHEXA	111012	111	111016	111009	111014	111015	121016	121009	+ 310
178-	+	310121014	121015							
179-	CHEXA	112005	112	111015	111014	111021	111022	121015	121014	+ 376
180-	+	376121021	121022							
181-	CHEXA	112010	112	111022	111021	111027	111028	121022	121021	+ 441
182-	+	441121027	121028							
183-	CHEXA	112015	112	111028	111027	111033	111034	121028	121027	+ 506
184-	+	506121033	121034							
185-	CHEXA	112020	112	111034	111033	111039	111040	121034	121033	+ 571
186-	+	571121039	121040							
187-	CHEXA	112025	112	111040	111039	111045	111046	121040	121039	+ 636
188-	+	636121045	121046							
189-	CHEXA	112030	112	111046	111045	111051	111052	121046	121045	+ 701
190-	+	701121051	121052							
191-	CHEXA	113005	113	111052	111051	111057	111058	121052	121051	+ 766
192-	+	766121057	121058							
193-	CHEXA	121012	121	121016	121009	121014	121015	131016	131009	+ 311
194-	+	311131014	131015							
195-	CHEXA	122005	122	121015	121014	121021	121022	131015	131014	+ 377
196-	+	377131[illegible]	131022							
197-	CHEXA	122010	122	121022	121021	121027	121028	131022	131021	+ 442
198-	+	442131027	131028							
199-	CHEXA	122[illegible]5	122	121028	121027	121033	121034	131028	131027	+ 507
200-	+	507131033	131034							

MODEL C2.2 (PHASE 2) 13 LAYER CRITICAL STRIP   OCTOBER 25, 1978   NASTRAN 3/11/78
C2-PRE-PROCESSOR PRODUCED BULK DATA

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
201-	CHEXA	122020	122	121034	121033	121039	121040	131034	131033	+ 572
202-	+	572131039	131040							
203-	CHEXA	122025	122	121040	121039	121045	121046	131040	131039	+ 637
204-	+	637131045	131046							
205-	CHEXA	122030	122	121046	121045	121051	121052	131046	131045	+ 702
206-	+	702131051	131052							
207-	CHEXA	123005	123	121052	121051	121057	121058	131052	131051	+ 767
208-	+	767131057	131058							
209-	CORD2C	100		.6700	.1700	.0	.6700	.1700	1.0	+ 312
210-	+	3121.6700	.1700	.0						
211-	GRID	1009		.6291	.2950	.1000				
212-	GRID	1014		.6700	.2950	.1000				
213-	GRID	1015		.6700	.2950	.0				
214-	GRID	1016		.6500	.2950	.0				
215-	GRID	1021	100	.1250	75.0000	.1000				
216-	GRID	1022	100	.1250	75.0000	.0				
217-	GRID	1027	100	.1250	60.0000	.1000				
218-	GRID	1028	100	.1250	60.0000	.0				
219-	GRID	1033	100	.1250	45.0000	.1000				
220-	GRID	1034	100	.1250	45.0000	.0				
221-	GRID	1039	100	.1250	30.0000	.1000				
222-	GRID	1040	100	.1250	30.0000	.0				
223-	GRID	1045	100	.1250	15.0000	.1000				
224-	GRID	1046	100	.1250	15.0000	.0				
225-	GRID	1051	100	.1250	.0	.1000				
226-	GRID	1052	100	.1250	.0	.0				
227-	GRID	1057		.7950	.0	.1000				
228-	GRID	1058		.7950	.0	.0				
229-	GRID	11009		.6291	.3050	.1000				
230-	GRID	11014		.6700	.3050	.1000				
231-	GRID	11015		.6700	.3050	.0				
232-	GRID	11016		.6500	.3050	.0				
233-	GRID	11021	100	.1350	75.0000	.1000				
234-	GRID	11022	100	.1350	75.0000	.0				
235-	GRID	11027	100	.1350	60.0000	.1000				
236-	GRID	11028	100	.1350	60.0000	.0				
237-	GRID	11033	100	.1350	45.0000	.1000				
238-	GRID	11034	100	.1350	45.0000	.0				
239-	GRID	11039	100	.1350	30.0000	.1000				
240-	GRID	11040	100	.1350	30.0000	.0				
241-	GRID	11045	100	.1350	15.0000	.1000				
242-	GRID	11046	100	.1350	15.0000	.0				
243-	GRID	11051	100	.1350	.0	.1000				
244-	GRID	11052	100	.1350	.0	.0				
245-	GRID	11057		.8050	.0	.1000				
246-	GRID	11058		.8050	.0	.0				
247-	GRID	21009		.6291	.3150	.1000				
248-	GRID	21014		.6700	.3150	.1000				
249-	GRID	21015		.6700	.3150	.0				
250-	GRID	21016		.6500	.3150	.0				

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
251-	GRID	21021	100	.1450	75.0000	.1000				
252-	GRID	21022	100	.1450	75.0000	.0				
253-	GRID	21027	100	.1450	60.0000	.1000				
254-	GRID	21028	100	.1450	60.0000	.0				
255-	GRID	21033	100	.1450	45.0000	.1000				
256-	GRID	21034	100	.1450	45.0000	.0				
257-	GRID	21039	100	.1450	30.0000	.1000				
258-	GRID	21040	100	.1450	30.0000	.0				
259-	GRID	21045	100	.1450	15.0000	.1000				
260-	GRID	21046	100	.1450	15.0000	.0				
261-	GRID	21051	100	.1450	.0	.1000				
262-	GRID	21052	100	.1450	.0	.0				
263-	GRID	21057		.8150	.0	.1000				
264-	GRID	21058		.8150	.0	.0				
265-	GRID	31009		.6291	.3250	.1000				
266-	GRID	31014		.6700	.3250	.1000				
267-	GRID	31015		.6700	.3250	.0				
268-	GRID	31016		.6500	.3250	.0				
269-	GRID	31021	100	.1550	75.0000	.1000				
270-	GRID	31022	100	.1550	75.0000	.0				
271-	GRID	31027	100	.1550	60.0000	.1000				
272-	GRID	31028	100	.1550	60.0000	.0				
273-	GRID	31033	100	.1550	45.0000	.1000				
274-	GRID	31034	100	.1550	45.0000	.0				
275-	GRID	31039	100	.1550	30.0000	.1000				
276-	GRID	31040	100	.1550	30.0000	.0				
277-	GRID	31045	100	.1550	15.0000	.1000				
278-	GRID	31046	100	.1550	15.0000	.0				
279-	GRID	31051	100	.1550	.0	.1000				
280-	GRID	31052	100	.1550	.0	.0				
281-	GRID	31057		.8250	.0	.1000				
282-	GRID	31058		.8250	.0	.0				
283-	GRID	41009		.6291	.3350	.1000				
284-	GRID	41014		.6700	.3350	.1000				
285-	GRID	41015		.6700	.3350	.0				
286-	GRID	41016		.6500	.3350	.0				
287-	GRID	41021	100	.1650	75.0000	.1000				
288-	GRID	41022	100	.1650	75.0000	.0				
289-	GRID	41027	100	.1650	60.0000	.1000				
290-	GRID	41028	100	.1650	60.0000	.0				
291-	GRID	41033	100	.1650	45.0000	.1000				
292-	GRID	41034	100	.1650	45.0000	.0				
293-	GRID	41039	100	.1650	30.0000	.1000				
294-	GRID	41040	100	.1650	30.0000	.0				
295-	GRID	41045	100	.1650	15.0000	.1000				
296-	GRID	41046	100	.1650	15.0000	.0				
297-	GRID	41051	100	.1650	.0	.1000				
298-	GRID	41052	100	.1650	.0	.0				
299-	GRID	41057		.8350	.0	.1000				
300-	GRID	41058		.8350	.0	.0				

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
301-	GRID	51009		.6291	.3450	.1000				
302-	GRID	51014		.6700	.3450	.1000				
303-	GRID	51015		.6700	.3450	.0				
304-	GRID	51016		.6500	.3450	.0				
305-	GRID	51021	100	.1750	75.0000	.1000				
306-	GRID	51022	100	.1750	75.0000	.0				
307-	GRID	51027	100	.1750	60.0000	.1000				
308-	GRID	51028	100	.1750	60.0000	.0				
309-	GRID	51033	100	.1750	45.0000	.1000				
310-	GRID	51034	100	.1750	45.0000	.0				
311-	GRID	51039	100	.1750	30.0000	.1000				
312-	GRID	51040	100	.1750	30.0000	.0				
313-	GRID	51045	100	.1750	15.0000	.1000				
314-	GRID	51046	100	.1750	15.0000	.0				
315-	GRID	51051	100	.1750	.0	.1000				
316-	GRID	51052	100	.1750	.0	.0				
317-	GRID	51057		.8450	.0	.1000				
318-	GRID	51058		.8450	.0	.0				
319-	GRID	61009		.6291	.3550	.1000				
320-	GRID	61014		.6700	.3550	.1000				
321-	GRID	61015		.6700	.3550	.0				
322-	GRID	61016		.6500	.3550	.0				
323-	GRID	61021	100	.1650	75.0000	.1000				
324-	GRID	61022	100	.1850	75.0000	.0				
325-	GRID	61027	100	.1850	60.0000	.1000				
326-	GRID	61028	100	.1850	60.0000	.0				
327-	GRID	61033	100	.1850	45.0000	.1000				
328-	GRID	61034	100	.1850	45.0000	.0				
329-	GRID	61039	100	.1850	30.0000	.1000				
330-	GRID	61040	100	.1850	30.0000	.0				
331-	GRID	61045	100	.1850	15.0000	.1000				
332-	GRID	61046	100	.1850	15.0000	.0				
333-	GRID	61051	100	.1850	.0	.1000				
334-	GRID	61052	100	.1850	.0	.0				
335-	GRID	61057		.8550	.0	.1000				
336-	GRID	61058		.8550	.0	.0				
337-	GRID	71009		.6291	.3600	.1000				
338-	GRID	71014		.6700	.3600	.1000				
339-	GRID	71015		.6700	.3600	.0				
340-	GRID	710[illegible]		[illegible]	.3600	.0				
341-	GRID	71021	100	.1900	75.0000	.1000				
342-	GRID	71022	100	.1900	75.0000	.0				
343-	GRID	71027	100	.1900	60.0000	.1000				
344-	GRID	71028	100	.1900	60.0000	.0				
345-	GRID	71033	100	.1900	45.0000	.1000				
346-	GRID	71034	100	.1900	45.0000	.0				
347-	GRID	71039	100	.1900	30.0000	.1000				
348-	GRID	71040	100	.1900	30.0000	.0				
349-	GRID	71045	100	.1900	15.0000	.1000				
350-	GRID	71046	100	.1900	15.0000	.0				

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
351-	GRID	71051	100	.1900	.0	.1000				
352-	GRID	71052	100	.1900	.0	.0				
353-	GRID	71057		.8600	.0	.1000				
354-	GRID	71058		.8600	.0	.0				
355-	GRID	81009		.6291	.3700	.1000				
356-	GRID	81014		.6700	.3700	.1000				
357-	GRID	81015		.6700	.3700	.0				
358-	GRID	81016		.6500	.3700	.0				
359-	GRID	81021	100	.2000	75.0000	.1000				
360-	GRID	81022	100	.2000	75.0000	.0				
361-	GRID	81027	100	.2000	60.0000	.1000				
362-	GRID	81028	100	.2000	60.0000	.0				
363-	GRID	81033	100	.2000	45.0000	.1000				
364-	GRID	81034	100	.2000	45.0000	.0				
365-	GRID	81039	100	.2000	30.0000	.1000				
366-	GRID	81040	100	.2000	30.0000	.0				
367-	GRID	81045	100	.2000	15.0000	.1000				
368-	GRID	81046	100	.2000	15.0000	.0				
369-	GRID	81051	100	.2000	.0	.1000				
370-	GRID	81052	100	.2000	.0	.0				
371-	GRID	81057		.8700	.0	.1000				
372-	GRID	81058		.8700	.0	.0				
373-	GRID	91009		.6291	.3800	.1000				
374-	GRID	91014		.6700	.3800	.1000				
375-	GRID	91015		.6700	.3800	.0				
376-	GRID	91016		.6500	.3800	.0				
377-	GRID	91021	100	.2100	75.0000	.1000				
378-	GRID	91022	100	.2100	75.0000	.0				
379-	GRID	91027	100	.2100	60.0000	.1000				
380-	GRID	91028	100	.2100	60.0000	.0				
381-	GRID	91033	100	.2100	45.0000	.1000				
382-	GRID	91034	100	.2100	45.0000	.0				
383-	GRID	91039	100	.2100	30.0000	.1000				
384-	GRID	91040	100	.2100	30.0000	.0				
385-	GRID	91045	100	.2100	15.0000	.1000				
386-	GRID	91046	100	.2100	15.0000	.0				
387-	GRID	[illegible]	100	.2100	.0	.1000				
388-	GRID	91052	100	.2100	.0	.0				
389-	GRID	91057		.8800	.0	.1000				
390-	GRID	91058		.8800	.0	.0				
391-	GRID	101009		.6291	.3900	.1000				
392-	GRID	101014		.6700	.3900	.1000				
393-	GRID	101015		.6700	.3900	.0				
394-	GRID	101016		.6500	.3900	.0				
395-	GRID	101021	100	.2200	75.0000	.1000				
396-	GRID	101022	100	.2200	75.0000	.0				
397-	GRID	101027	100	.2200	60.0000	.1000				
398-	GRID	101028	100	.2200	60.0000	.0				
399-	GRID	101033	100	.2200	45.0000	.1000				
400-	GRID	101034	100	.2200	45.0000	.0				

MODEL C2.2 (PHASE 2) 13-LAYER CRITICAL STRIP OCTOBER 25, 1978 NASTRAN 3/11/78
C2-PRE-PROCESSOR PRODUCED BULK DATA

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
401-	GRID	101039	100	.2200	30.0000	.1000	
402-	GRID	101040	100	.2200	30.0000	.0	
403-	GRID	101045	100	.2200	15.0000	.1000	
404-	GRID	101046	100	.2200	15.0000	.0	
405-	GRID	101051	100	.2200	.0	.1000	
406-	GRID	101052	100	.2200	.0	.0	
407-	GRID	101057		.8900	.0	.1000	
408-	GRID	101058		.8900	.0	.0	
409-	GRID	111009		.6291	.4000	.1000	
410-	GRID	111014		.6700	.4000	.1000	
411-	GRID	111015		.6700	.4000	.0	
412-	GRID	111016		.6500	.4000	.0	
413-	GRID	111021	100	.2300	75.0000	.1000	
414-	GRID	111022	100	.2300	75.0000	.0	
415-	GRID	111027	100	.2300	60.0000	.1000	
416-	GRID	111028	100	.2300	60.0000	.0	
417-	GRID	111033	100	.2300	45.0000	.1000	
418-	GRID	111034	100	.2300	45.0000	.0	
419-	GRID	111039	100	.2300	30.0000	.1000	
420-	GRID	111040	100	.2300	30.0000	.0	
421-	GRID	111045	100	.2300	15.0000	.1000	
422-	GRID	111046	100	.2300	15.0000	.0	
423-	GRID	111051	100	.2300	.0	.1000	
424-	GRID	111052	100	.2300	.0	.0	
425-	GRID	111057		.9000	.0	.1000	
426-	GRID	111058		.9000	.0	.0	
427-	GRID	121009		.6291	.4100	.1000	
428-	GRID	121014		.6700	.4100	.1000	
429-	GRID	121015		.6700	.4100	.0	
430-	GRID	121016		.6500	.4100	.0	
431-	GRID	121021	100	.2400	75.0000	.1000	
432-	GRID	121022	100	.2400	75.0000	.0	
433-	GRID	121027	100	.2400	60.0000	.1000	
434-	GRID	121028	100	.2400	60.0000	.0	
435-	GRID	121033	100	.2400	45.0000	.1000	
436-	GRID	121034	100	.2400	45.0000	.0	
437-	GRID	121039	100	.2400	30.0000	.1000	
438-	GRID	121040	100	.2400	30.0000	.0	
439-	GRID	121045	100	.2400	15.0000	.1000	
440-	GRID	121046	100	.2400	15.0000	.0	
441-	GRID	121051	100	.2400	.0	.1000	
442-	GRID	121052	100	.2400	.0	.0	
443-	GRID	121057		.9100	.0	.1000	
444-	GRID	121058		.9100	.0	.0	
445-	GRID	131009		.6291	.4200	.1000	
446-	GRID	131014		.6700	.4200	.1000	
447-	GRID	131015		.6700	.4200	.0	
448-	GRID	131016		.6500	.4200	.0	
449-	GRID	131021	100	.2500	75.0000	.1000	
450-	GRID	131022	100	.2500	75.0000	.0	

MODEL C2.2 (PHASE 2) 13-LAYER CRITICAL STRIP OCTOBER 25, 1978 NASTRAN 3/11/78
C2-PRE-PROCESSOR PRODUCED BULK DATA

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
451-	GRID	131027	100	.2500	60.0000	.1000	
452-	GRID	131028	100	.2500	60.0000	.0	
453-	GRID	131033	100	.2500	45.0000	.1000	
454-	GRID	131034	100	.2500	45.0000	.0	
455-	GRID	131039	100	.2500	30.0000	.1000	
456-	GRID	131040	100	.2500	30.0000	.0	
457-	GRID	131045	100	.2500	15.0000	.1000	
458-	GRID	131046	100	.2500	15.0000	.0	
459-	GRID	131051	100	.2500	.0	.1000	
460-	GRID	131052	100	.2500	.0	.0	
461-	GRID	131057		.9200	.0	.1000	
462-	GRID	131058		.9200	.0	.0	
	ENDDATA						

TOTAL COUNT= 462

```
      N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
  1  BEGIN    NO. 24 -LINEAR STATIC ANALYSIS 7 JUN 1976 $
  2  PARAM    //DIAGON//47 $
  3  FILE     GM=SAVE / KNN=SAVE / MNN=SAVE $
  4  FILE     UG=APPEND/PGG=APPEND/UGV=APPEND $
  5  SETVAL   //V,N,CARDNO/0 $
  6  SETVAL   //V,N,MODS/1/V,N,NOMOD/-1 $
  7  SETVAL   //V,N,NOKGGX/1 $
  8  SETVAL   //V,N,NOMGGX/1 $
  9  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/S,N,LUSET/0/S,N,
              NOGPDT $
 10  COND     ERROR,NOGPDT $
 11  GP2      GEOM2,EQEXIN/ECT $
 12  PARAML   PCDB//PRES////V,N,JUMPPLOT $
 13  COND     P1,JUMPPLOT $
 14  PARAM    //DIAGOFF//47 $
 15  PLTHBDY  GEOM2,ECT,EPT,SIL,EQEXIN,BGPDT/PECT,PSIL,PEQIN,PBGPDT/S,N,
              NHBDY/C,Y,MESH=NO $
 16  EQUIV    EQEXIN,PEQIN/NHBDY/ECT,PECT/NHBDY/BGPDT,PBGPDT/NHBDY/ SIL,PSIL/
              NHBDY $
 17  PLTSET   PCDB,PEQIN,PECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,NSIL/   S,N,
              JUMPPLOT $
 18  CHKPNT   PLTPAR,GPSETS,ELSETS $
 19  PRTMSG   PLTSETX// $
 20  SETVAL   //V,N,PLTFLG/1/ V,N,PFILE/0 $
 21  COND     P1,JUMPPLOT $
 22  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,PBGPDT,PEQIN,PSIL,,PECT,,/PLOTX1/
              NSIL/LUSET/S,N,JUMPPLOT/S,N,PLTFLG/S,N,PFILE $
 23  PRTMSG   PLOTX1//$
 23  EXIT $
 24  LABEL    P1 $
 25  PARAM    //DIAGON//47 $
 26  GP3      GEOM3,EQEXIN,GEOM2/SLT,ETT/S/V,N,NOGRAV/0 $
 27  COND     LMODS,MODS $
 28  TA1      ,ECT,EPT,BGPDT,SIL,ETT,CSTM/EST,,GEI,GPECT,/V,N,LUSET/0/   S,N,
              NOSIMP/1/S,N,NOGENL/S,N,GENEL $
 29  COND     CSKPLAG,NOSIMP $
 30  PARAM    //DIAGOFF//47 $
 31  EMG      EST,CSTM,MPT,DIT,GEOM2,,,/KELM,KDICT,MELM,MDICT,,/S,N,NOKGGX/
              S,N,NOMGGX/0///C,Y,COUPMASS $
 32  CHKPNT   KELM,KDICT $
 33  CHKPNT   MELM,MDICT $
 34  PARAM    //DIAGON//47 $
 35  PURGE    KGGX/NOKGGX $
 36  COND     LBMAP,NOKGGX $
 37  EMA      GPECT,KDICT,KELM,BGPDT,SIL,CSTM/KGGX, $
 38  LABEL    LBMAP $
 39  PURGE    MGGX/NOMGGX $
 40  COND     LMODS,NOMGGX $
 41  EMA      GPECT,MDICT,MELM,BGPDT,SIL,CSTM/MGGX,/-1/C,Y,WTMASS=1. $
```

```
MODEL C2.2 (PHASE 2) ELEVATED CRITICAL STRIP                         OCTOBER 29, 1976   NASTRAN 3/11/76
C2-PRE-PROCESSOR PRODUCED PLOT DATA

                                             MESSAGES FROM THE PLOT MODULE

P L O T T E R   D A T A

      THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

      PAPER SIZE = 20.0 X 20.0,  PAPER TYPE = VELLUM

      PEN 1 - SIZE 1, BLACK
      PEN 2 - SIZE 1, BLACK
      PEN 3 - SIZE 1, BLACK
      PEN 4 - SIZE 1, BLACK

E N G I N E E R I N G   D A T A

      ORTHOGRAPHIC PROJECTION
      ROTATIONS (DEGREES) - GAMMA =   0.0 , BETA =   0.0 , ALPHA =   0.0 ,  AXES = +Z,+X,+Y, SYMMETRIC
      SCALE (OBJECT-TO-PLOT SIZE) = 4.419664E+01

      ORIGIN      1  -  X0 =  2.494772E+01, Y0 = -9.600049E-01     (INCHES)

L I S T   O F   P L O T S

      PLOT    1     UNDEFORMED SHAPE

MODEL C2.2 (PHASE 2) ELEVATED CRITICAL STRIP                         OCTOBER 29, 1976   NASTRAN 3/11/76
C2-PRE-PROCESSOR PRODUCED PLOT DATA

                                             MESSAGES FROM THE PLOT MODULE

P L O T T E R   D A T A

      THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

      PAPER SIZE = 27.5 X 20.0,  PAPER TYPE = VELLUM

      PEN 1 - SIZE 1, BLACK
      PEN 2 - SIZE 1, BLACK
      PEN 3 - SIZE 1, BLACK
      PEN 4 - SIZE 1, BLACK

E N G I N E E R I N G   D A T A

      ORTHOGRAPHIC PROJECTION
      ROTATIONS (DEGREES) - GAMMA = -10.00, BETA =  20.00, ALPHA = -30.00,  AXES = +Z,+X,+Y, SYMMETRIC
      SCALE (OBJECT-TO-PLOT SIZE) = 3.445515E+01

      ORIGIN      1  -  X0 =  2.494772E+01, Y0 = -9.600049E-01     (INCHES)
      ORIGIN      5  -  X0 =  1.789540E+01, Y0 = -1.994650E+01     (INCHES)

L I S T   O F   P L O T S

      PLOT    2     UNDEFORMED SHAPE
```

14

F

MESSAGES FROM THE PLOT MODULE

P L O T T E R   D A T A

THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

PAPER SIZE = 20.0 X 20.0, PAPER TYPE = VELLUM

PEN 1 - SIZE 1, BLACK
PEN 2 - SIZE 1, BLACK
PEN 3 - SIZE 1, BLACK
PEN 4 - SIZE 1, BLACK

E N G I N E E R I N G   D A T A

ORTHOGRAPHIC PROJECTION
ROTATIONS (DEGREES) - GAMMA = -10.00, BETA = 20.00, ALPHA = -30.00, AXES = +Z,+X,+Y, SYMMETRIC
SCALE (OBJECT-TO-PLOT SIZE) = 5.257930E-01

ORIGIN	6	-	X0 = 2.494772E+01, Y0 = -9.600049E-01	(INCHES)
ORIGIN	5	-	X0 = 1.789546E+01, Y0 = -1.594650E+01	(INCHES)
ORIGIN	7	-	X0 = 2.704458E+01, Y0 = -2.505588E+01	(INCHES)

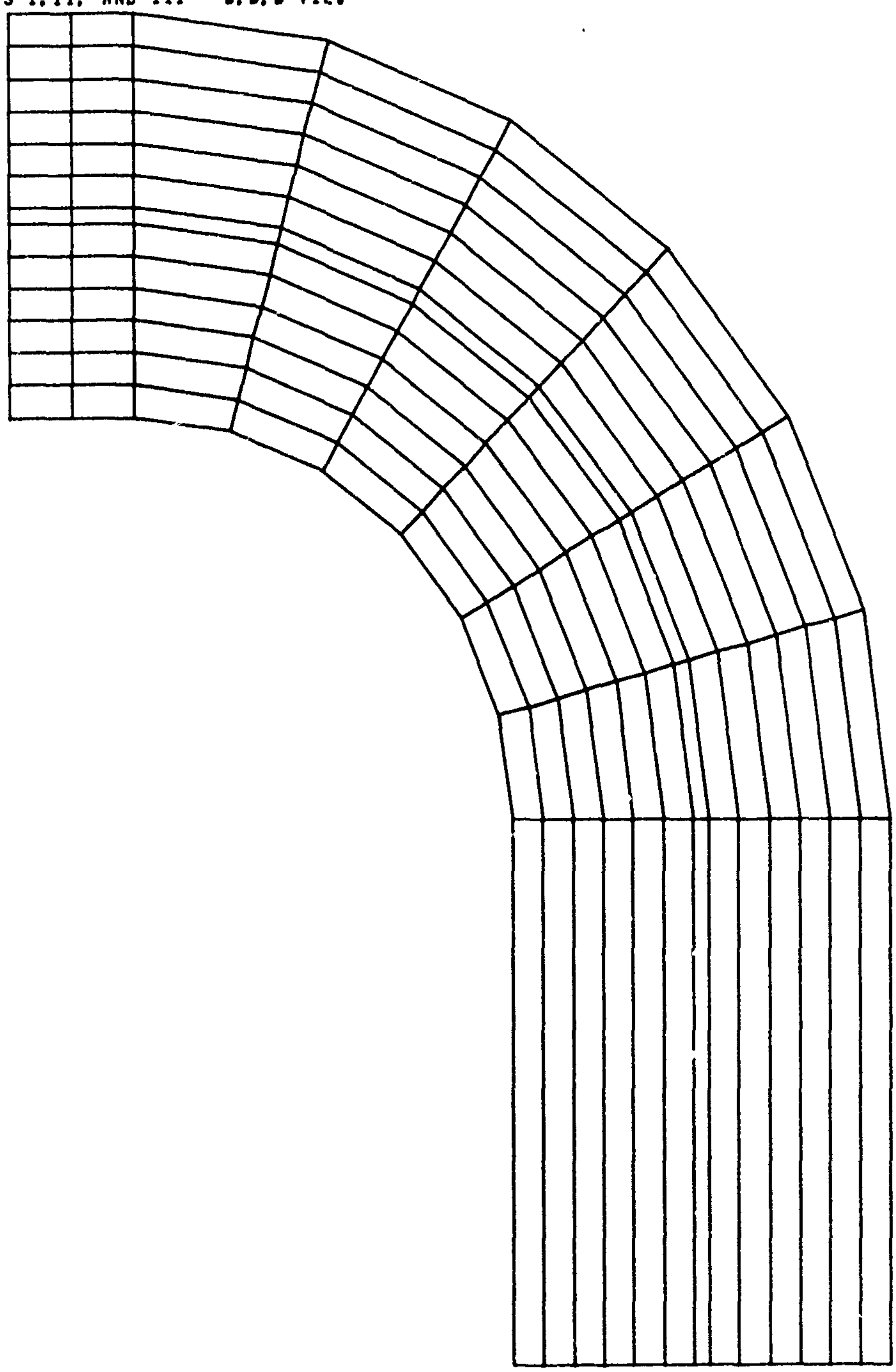
L I S T   O F   P L O T S

PLOT 3 UNDEFORMED SHAPE

14
B

```
MODEL C2.. (PHASE 2) 15 LAYER CRITICAL STRIP                         OCTOBER 25, 1976   NASTRAN  3/11/76
C2-PRE-PROCESSOR PRODUCED [illegible] DATA

                                        MESSAGES FROM THE PLOT MODULE


P L O T T E R   D A T A

      THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

      PAPER SIZE = 20.0 X 20.0,  PAPER TYPE = VELLUM

      PEN 1 - SIZE 1, BLACK
      PEN 2 - SIZE 1, BLACK
      PEN 3 - SIZE 1, BLACK
      PEN 4 - SIZE 1, BLACK


E N G I N E E R I N G   D A T A

      ORTHOGRAPHIC PROJECTION
      ROTATIONS (DEGREES) - GAMMA = -10.00, BETA =  20.00, ALPHA = -30.00,  AXES = +Z,+X,+Y, SYMMETRIC
      SCALE (OBJECT-TO-PLOT SIZE) = 5.257931E+01

      ORIGIN       [illegible]   -   XO =  3.494772E+01, YO = -9.100349E-01      (INCHES)
      ORIGIN       5   -   XO =  1.789540E+01, YO = -1.994050E+01      (INCHES)
      ORIGIN       7   -   XO =  2.704958E+01, YO = -2.515598E+01      (INCHES)

L I S T   O F   P L O T S

      PLOT    4     UNDEFORMED SHAPE
```

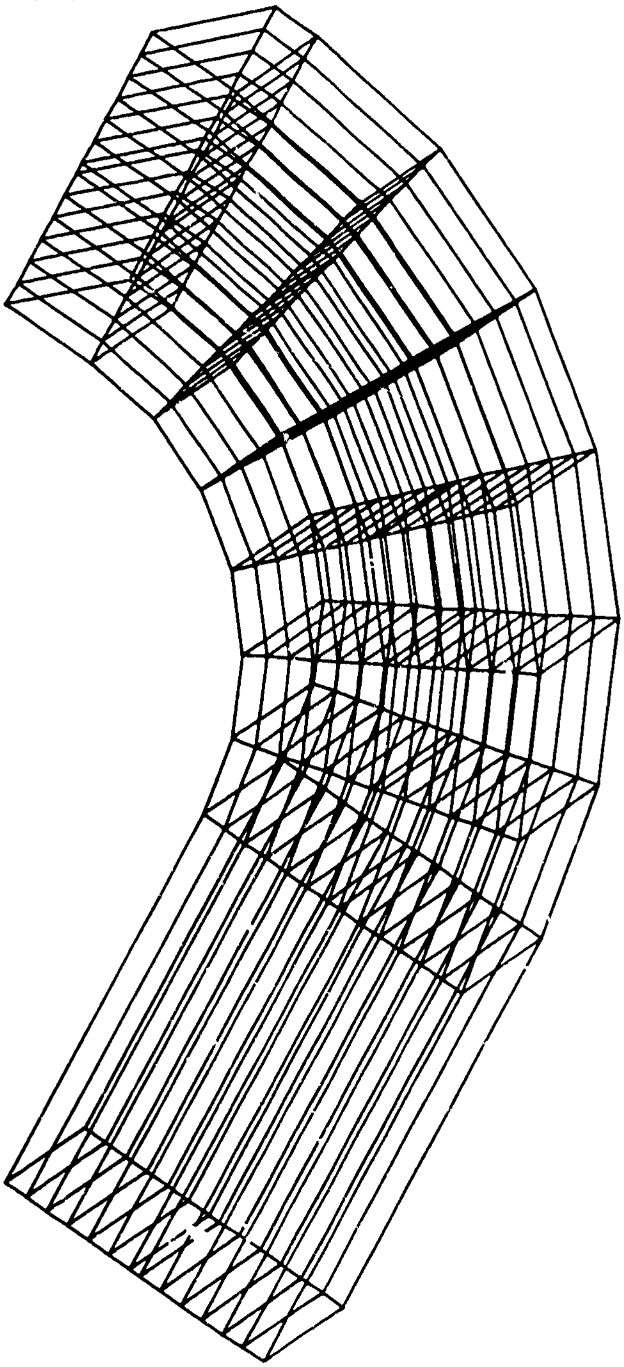
1 10/25/78
MESHES I,II, AND III - 0,0,0 VIEW



MODEL C2.2 (PHASE 2) 13 LAYER CRITICAL STRIP
C2-PRE-PROCESSOR PRODUCED BULK DATA

UNDEFORMED SHAPE

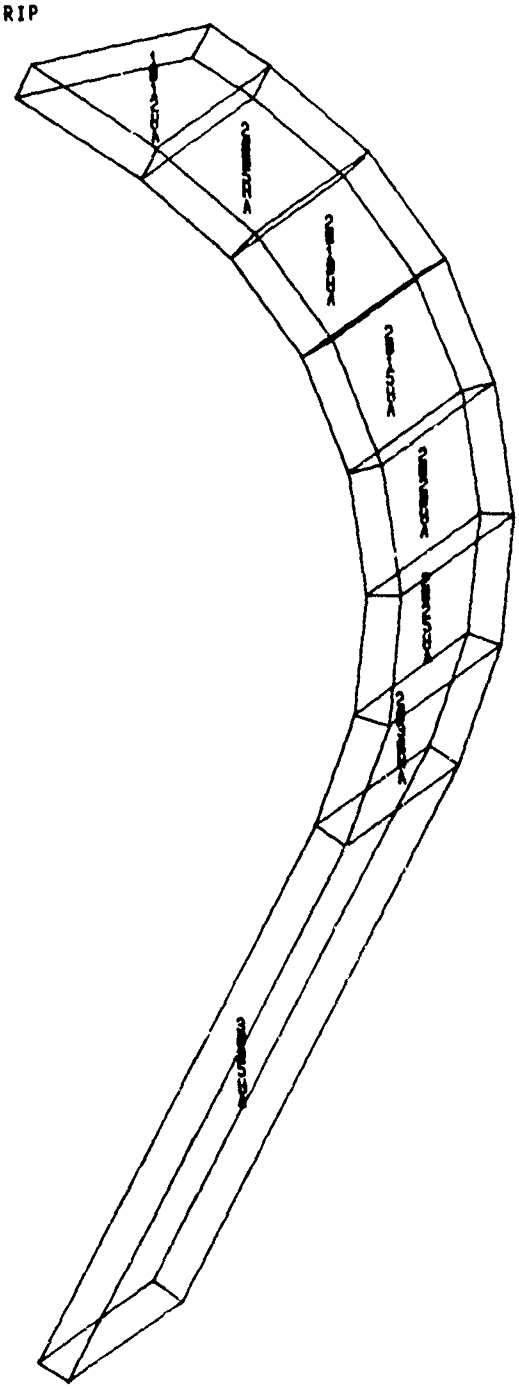
2 10/25/78
MESHES I,II, AND III -10,20,-30 VIEW



MODEL C2.2 (PHASE 2) 13 LAYER CRITICAL STRIP
C2-PRE-PROCESSOR PRODUCED BULK DATA

UNDEFORMED SHAPE

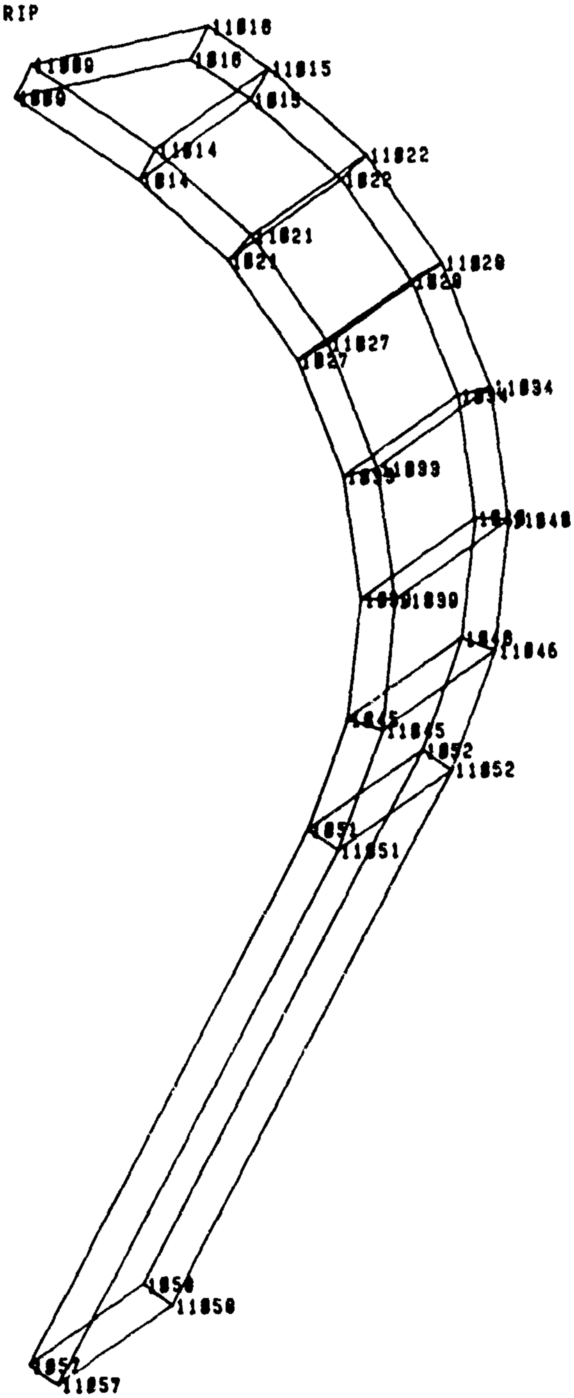
3 10/25/78
3-D VIEW OF ONE LAYER OF THE STRIP



MODEL C2.2 (PHASE 2) 13 LAYER CRITICAL STRIP
C2-PRE-PROCESSOR PRODUCED BULK DATA

UNDEFORMED SHAPE

4 10/25/79
3-D VIEW OF ONE LAYER OF THE STRIP



MODEL C2.2 (PHASE 2) 10 LAYER CRITICAL STRIP
C2-PRE-PROCESSOR PRODUCED BULK DATA

UNDEFORMED SHAPE

APPENDIX M

SINGLE STRIP NASTRAN OUTPUT

```
N A S T R A N

MSC - 46

VERSION MAR 11, 1976

IBM 360-370 SERIES

MODEL 65
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```
OCTOBER 26, 1976   NASTRAN 3/11/76

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

ID C2251SC2, STRESSES
SOL 24
TIME 25
DIAG 8,14
DIAG 22
CEND
```

```
                              C A S E    C O N T R O L    D E C K    E C H O
 CARD
 COUNT
   1      TITLE = COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)
   2      SUBTITLE = ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS
   3      $
   4      $ UNLIKE MODEL C1 RUN, LOADS ARE NOW APPLIED AS 2 SUBCASES
   5      $ WITH CORRESPONDING BOUNDARY CONDITIONS
   6      $
   7      SET 1 =   1014,  1015,  1021,  1022,  1027,  1028,  1033,  1034,
                    1039,  1040,  1045,  1046,  1051,  1052,  1057,  1058,
                131014,131015,131021,131022,131027,131028,131033,131034,
  10            131039,131040,131045,131046,131051,131052,131057,131058
  11      OLOAD = ALL
  12      DISPL = ALL
  13      STRESS = ALL
  14      SPCFORCE = ALL
  15      ESE = ALL
  16      GPFORCE = 1
  17      $
  18      SUBCASE 1
  19          LABEL = UNIFORM PULL, RSPLINE ELEMS USED FOR PARABOLIC DISTN
  20          SPC  = 20  $DISPL BCS FROM C1 RUN, SUBCOM 3 + WASHER + SYM BCS
  21      $
  22      SUBCASE 2
  23          LABEL = CLOCKWISE COUPLE, RSPLINE ELMS USED  FOR PARAB DISTN
  24          SPC  = 21  $DISPL BCS FROM C1 RUN, SUBCOM 4 + WASHER + SYM BCS
  25      BEGIN BULK
```

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)   OCTOBER 26, 1978   NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
1-	CBAR	1	6	251	1051	1052			2	
2-	CBAR	2	6	252	1052	1051			2	
3-	CBAR	3	6	251	252	1051			2	
4-	CHEXA	1012	1	1016	1009	1014	1015	11016	11009	+ 299
5-	+	29911014	11015							
6-	CHEXA	2005	2	1015	1014	1021	1022	11015	11014	+ 365
7-	+	36511021	11022							
8-	CHEXA	2010	2	1022	1021	1027	1028	11022	11021	+ 430
9-	+	43011027	11028							
10-	CHEXA	2015	2	1028	1027	1033	1034	11028	11027	+ 495
11-	+	49511033	11034							
12-	CHEXA	2020	2	1034	1033	1039	1040	11034	11033	+ 560
13-	+	56011039	11040							
14-	CHEXA	2025	2	1040	1039	1045	1046	11040	.11039	+ 625
15-	+	62511045	11046							
16-	CHEXA	2030	2	1046	1045	1051	1052	11046	11045	+ 690
17-	+	69011051	11052							
18-	CHEXA	3005	3	1052	1051	1057	1058	11052	11051	+ 755
19-	+	75511057	11058							
20-	CHEXA	11012	11	11016	11009	11014	11015	21016	21009	+ 300
21-	+	30021014	21015							
22-	CHEXA	12005	12	11015	11014	11021	11022	21015	21014	+ 366
23-	+	36621021	21022							
24-	CHEXA	12010	12	11022	11021	11027	11028	21022	21021	+ 431
25-	+	43121027	21028							
26-	CHEXA	12015	12	11028	11027	11033	11034	21028	21027	+ 496
27-	+	49621033	21034							
28-	CHEXA	12020	12	11034	11033	11039	11040	21034	21033	+ 561
29-	+	56121039	21040							
30-	CHEXA	12025	12	11040	11039	11045	11046	21040	21039	+ 626
31-	+	62621045	21046							
32-	CHEXA	12030	12	11046	11045	11051	11052	21046	21045	+ 691
33-	+	69121051	21052							
34-	CHEXA	13005	13	11052	11051	11057	11058	21052	21051	+ 756
35-	+	75621057	21058							
36-	CHEXA	21012	21	21016	21009	21014	21015	31016	31009	+ 301
37-	+	30131014	31015							
38-	CHEXA	22005	22	21015	21014	21021	21022	31015	31014	+ 367
39-	+	36731021	31022							
40-	CHEXA	22010	22	21022	21021	21027	21028	31022	31021	+ 432
41-	+	43231027	31028							
42-	CHEXA	22015	22	21028	21027	21033	21034	31028	31027	+ 497
43-	+	49731033	31034							
44-	CHEXA	22020	22	21034	21033	21039	21040	31034	31033	+ 562
45-	+	56231039	31040							
46-	CHEXA	22025	22	21040	21039	21045	21046	31040	31039	+ 627
47-	+	62731045	31046							
48-	CHEXA	22030	22	21046	21045	21051	21052	31046	31045	+ 692
49-	+	69231051	31052							
50-	CHEXA	23005	23	21052	21051	21057	21058	31052	31051	+ 757

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
51-	+	75731057	31058							
52-	CHEXA	31012	31	31016	31009	31014	31015	41016	41009	+ 302
53-	+	30241014	41015							
54-	CHEXA	32005	32	31015	31014	31021	31022	41015	41014	+ 368
55-	+	36841021	41022							
56-	CHEXA	32010	32	31022	31021	31027	31028	41022	41021	+ 433
57-	+	43341027	41028							
58-	CHEXA	32015	32	31028	31027	31033	31034	41028	41027	+ 498
59-	+	49841033	41034							
60-	CHEXA	32020	32	31034	31033	31039	31040	41034	41033	+ 563
61-	+	56341039	41040							
62-	CHEXA	32025	32	31040	31039	31045	31046	41040	41039	+ 628
63-	+	62841045	41046							
64-	CHEXA	32030	32	31046	31045	31051	31052	41046	41045	+ 693
65-	+	69341051	41052							
66-	CHEXA	33005	33	31052	31051	31057	31058	41052	41051	+ 758
67-	+	75841057	41058							
68-	CHEXA	41012	41	41016	41009	41014	41015	51016	51009	+ 303
69-	+	30351014	51015							
70-	CHEXA	42005	42	41015	41014	41021	41022	51015	51014	+ 369
71-	+	36951021	51022							
72-	CHEXA	42010	42	41022	41021	41027	41028	51022	51021	+ 434
73-	+	43451027	51028							
74-	CHEXA	42015	42	41028	41027	41033	41034	51028	51027	+ 499
75-	+	49951033	51034							
76-	CHEXA	42020	42	41034	41033	41039	41040	51034	51033	+ 564
77-	+	56451039	51040							
78-	CHEXA	42025	42	41040	41039	41045	41046	51040	51039	+ 629
79-	+	62951045	51046							
80-	CHEXA	42030	42	41046	41045	41051	41052	51046	51045	+ 694
81-	+	69451051	51052							
82-	CHEXA	43005	43	41052	41051	41057	41058	51052	51051	+ 759
83-	+	75951057	51058							
84-	CHEXA	51012	51	51016	51009	51014	51015	61016	61009	+ 304
85-	+	30461014	61015							
86-	CHEXA	52005	52	51015	51014	51021	51022	61015	61014	+ 370
87-	+	37061021	61022							
88-	CHEXA	52010	52	51022	51021	51027	51028	61022	61021	+ 435
89-	+	43561027	61028							
90-	CHEXA	52015	52	51028	51027	51033	51034	61028	61027	+ 500
91-	+	50061033	61034							
92-	CHEXA	52020	52	51034	51033	51039	51040	61034	61033	+ 565
93-	+	56561039	61040							
94-	CHEXA	52025	52	51040	51039	51045	51046	61040	61039	+ 630
95-	+	63061045	61046							
96-	CHEXA	52030	52	51046	51045	51051	51052	61046	61045	+ 695
97-	+	69561051	61052							
98-	CHEXA	53005	53	51052	51051	51057	51058	61052	61051	+ 760
99-	+	76061057	61058							
100-	CHEXA	61012	61	61016	61009	61014	61015	71016	71009	+ 305

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2) OCTOBER 26, 1978 NASTRAN 3/1/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
101-	+	30571014	71015							
102-	CHEXA	62005	62	61015	61014	61021	61022	71015	71014	+ 371
103-	+	37171021	71022							
104-	CHEXA	62010	62	61022	61021	61027	61028	71022	71021	+ 436
105-	+	43671027	71028							
106-	CHEXA	62015	62	61028	61027	61033	61034	71028	71027	+ 501
107-	+	50171033	71034							
108-	CHEXA	62020	62	61034	61033	61039	61040	71034	71033	+ 566
109-	+	56671039	71040							
110-	CHEXA	62025	62	61040	61039	61045	61046	71040	71039	+ 631
111-	+	63171045	71046							
112-	CHEXA	62030	62	61046	61045	61051	61052	71046	71045	+ 696
113-	+	69671051	71052							
114-	CHEXA	63005	63	61052	61051	61057	61058	71052	71051	+ 761
115-	+	76171057	71058							
116-	CHEXA	71012	71	71016	71009	71014	71015	81016	81009	+ 306
117-	+	30681014	81015							
118-	CHEXA	72005	72	71015	71014	71021	71022	81015	81014	+ 372
119-	+	37281021	81022							
120-	CHEXA	72010	72	71022	71021	71027	71028	81022	81021	+ 437
121-	+	43781027	81028							
122-	CHEXA	72015	72	71028	71027	71033	71034	81028	81027	+ 502
123-	+	50281033	81034							
124-	CHEXA	72020	72	71034	71033	71039	71040	81034	81033	+ 567
125-	+	56781039	81040							
126-	CHEXA	72025	72	71040	71039	71045	71046	81040	81039	+ 632
127-	+	63281045	81046							
128-	CHEXA	72030	72	71046	71045	71051	71052	81046	81045	+ 697
129-	+	69781051	81052							
130-	CHEXA	73005	73	71052	71051	71057	71058	81052	81051	+ 762
131-	+	76281057	81058							
132-	CHEXA	81012	81	81016	81009	81014	81015	91016	91009	+ 307
133-	+	30791014	91015							
134-	CHEXA	82005	82	81015	81014	81021	81022	91015	91014	+ 373
135-	+	37391021	91022							
136-	CHEXA	82010	82	81022	81021	81027	81028	91022	91021	+ 438
137-	+	43891027	91028							
138-	CHEXA	82015	82	81028	81027	81033	81034	91028	91027	+ 503
139-	+	50391033	91034							
140-	CHEXA	82020	82	81034	81033	81039	81040	91034	91033	+ 568
141-	+	56891039	91040							
142-	CHEXA	82025	82	81040	81039	81045	81046	91040	91039	+ 633
143-	+	63391045	91046							
144-	CHEXA	82030	82	81046	81045	81051	81052	91046	91045	+ 698
145-	+	69891051	91052							
146-	CHEXA	83005	83	81052	81051	81057	81058	91052	91051	+ 763
147-	+	76391057	91058							
148-	CHEXA	91012	91	91016	91009	91014	91015	101016	101009	+ 308
149-	+	308101014	101015							
150-	CHEXA	92005	92	91015	91014	91021	91022	101015	101014	+ 374

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
151-	+	374101021	101022							
152-	CHEXA	92010	92	91022	91021	91027	91028	101022	101021	+ 439
153-	+	439101027	101028							
154-	CHEXA	92015	92	91028	91027	91033	91034	101028	101027	+ 504
155-	+	504101033	101034							
156-	CHEXA	92020	92	91034	91033	91039	91040	101034	101033	+ 569
157-	+	569101039	101040							
158-	CHEXA	92025	92	91040	91039	91045	91046	101040	101039	+ 634
159-	+	634101045	101046							
160-	CHEXA	92030	92	91046	91045	91051	91052	101046	101045	+ 699
161-	+	699101051	101052							
162-	CHEXA	93005	93	91052	91051	91057	91058	101052	101051	+ 764
163-	+	764101057	101058							
164-	CHEXA	101012	101	101016	101009	101014	101015	111016	111009	+ 309
165-	+	309111014	111015							
166-	CHEXA	102005	102	101015	101014	101021	101022	111015	111014	+ 375
167-	+	375111021	111022							
168-	CHEXA	102010	102	101022	101021	101027	101028	111022	111021	+ 440
169-	+	440111027	111028							
170-	CHEXA	102015	102	101028	101027	101033	101034	111028	111027	+ 505
171-	+	505111033	111034							
172-	CHEXA	102020	102	101034	101033	101039	101040	111034	111033	+ 570
173-	+	570111039	111040							
174-	CHEXA	102025	102	101040	101039	101045	101046	111040	111039	+ 635
175-	+	635111045	111046							
176-	CHEXA	102030	102	101046	101045	101051	101052	111046	111045	+ 700
177-	+	700111051	111052							
178-	CHEXA	103005	103	101052	101051	101057	101058	111052	111051	+ 765
179-	+	765111057	111058							
180-	CHEXA	111012	111	111016	111009	111014	111015	121016	121009	+ 310
181-	+	310121014	121015							
182-	CHEXA	112005	112	111015	111014	111021	111022	121015	121014	+ 376
183-	+	376121021	121022							
184-	CHEXA	112010	112	111022	111021	111027	111028	121022	121021	+ 441
185-	+	441121027	121028							
186-	CHEXA	112015	112	111028	111027	111033	111034	121028	121027	+ 506
187-	+	506121033	121034							
188-	CHEXA	112020	112	111034	111033	111039	111040	121034	121033	+ 571
189-	+	571121039	121040							
190-	CHEXA	112025	112	111040	111039	111045	111046	121040	121039	+ 636
191-	+	636121045	121046							
192-	CHEXA	112030	112	111046	111045	111051	111052	121046	121045	+ 701
193-	+	701121051	121052							
194-	CHEXA	113005	113	111052	111051	111057	111058	121052	121051	+ 766
195-	+	766121057	121058							
196-	CHEXA	121012	121	121016	121009	121014	121015	131016	131009	+ 311
197-	+	311131014	131015							
198-	CHEXA	122005	122	121015	121014	121021	121022	131015	131014	+ 377
199-	+	377131021	131022							
200-	CHEXA	122010	122	121022	121021	121027	121028	131022	131021	+ 442

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                                  S O R T E D   B U L K   D A T A   E C H O
 CARD
 COUNT        .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ...   9  ..  10  ..
  201-        +     442131027 131028
  202-        CHEXA   122015  122     121028  121027  121033  121034  131028  131027  +     507
  203-        +     507131033 131034
  204-        CHEXA   122020  122     121034  121033  121039  121040  131034  131033  +     572
  205-        +     572131039 131040
  206-        CHEXA   122025  122     121040  121039  121045  121046  131040  131039  +     637
  207-        +     637131045 131046
  208-        CHEXA   122030  122     121046  121045  121051  121052  131046  131045  +     702
  209-        +     702131051 131052
  210-        CHEXA   123005  123     121052  121051  121057  121058  131052  131051  +     767
  211-        +     767131057 131058
  212-        CORD2C  100             .6700   .1700   .0      .6700   .1700   1.0     +     312
  213-        +     3121.6700 .1700   .0
  214-        CORD2R  50              .0      .5      .0      .0      .5      .1      +CORD2R
  215-        +CORD2R .0      .6      .0
  216-        GRDSET                                                  456
  217-        GRID    251     100     .05     .0      .1
  218-        GRID    252     100     .05     .0      .0
  219-        GRID    1009            .6291   .2950   .1000
  220-        GRID    1014            .6700   .2950   .1000
  221-        GRID    1015            .6700   .2950   .0
  222-        GRID    1016            .6500   .2950   .0
  223-        GRID    1021    100     .1250   75.0000 .1000
  224-        GRID    1022    100     .1250   75.0000 .0
  225-        GRID    1027    100     .1250   60.0000 .1000
  226-        GRID    1028    100     .1250   60.0000 .0
  227-        GRID    1033    100     .1250   45.0000 .1000
  228-        GRID    1034    100     .1250   45.0000 .0
  229-        GRID    1039    100     .1250   30.0000 .1000
  230-        GRID    1040    100     .1250   30.0000 .0
  231-        GRID    1045    100     .1250   15.0000 .1000
  232-        GRID    1046    100     .1250   15.0000 .0
  233-        GRID    1051    100     .1250   .0      .1000
  234-        GRID    1052    100     .1250   .0      .0
  235-        GRID    1057            .7950   .0      .1000
  236-        GRID    1058            .7950   .0      .0
  237-        GRID    11009           .6291   .3050   .1000
  238-        GRID    11014           .6700   .3050   .1000
  239-        GRID    11015           .6700   .3050   .0
  240-        GRID    11016           .6500   .3050   .0
  241-        GRID    11021   100     .1350   75.0000 .1000
  242-        GRID    11022   100     .1350   75.0000 .0
  243-        GRID    11027   100     .1350   60.0000 .1000
  244-        GRID    11028   100     .1350   60.0000 .0
  245-        GRID    11033   100     .1350   45.0000 .1000
  246-        GRID    11034   100     .1350   45.0000 .0
  247-        GRID    11039   100     .1350   30.0000 .1000
  248-        GRID    11040   100     .1350   30.0000 .0
  249-        GRID    11045   100     .1350   15.0000 .1000
  250-        GRID    11046   100     .1350   15.0000 .0
```

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
251-	GRID	11051	100	.1350	.0	.1000				
252-	GRID	11052	100	.1350	.0	.0				
253-	GRID	11057		.8050	.0	.1000				
254-	GRID	11058		.8050	.0	.0				
255-	GRID	21009		.6291	.3150	.1000				
256-	GRID	21014		.6700	.3150	.1000				
257-	GRID	21015		.6700	.3150	.0				
258-	GRID	21016		.6500	.3150	.0				
259-	GRID	21021	100	.1450	75.0000	.1000				
260-	GRID	21022	100	.1450	75.0000	.0				
261-	GRID	21027	100	.1450	60.0000	.1000				
262-	GRID	21028	100	.1450	60.0000	.0				
263-	GRID	21033	100	.1450	45.0000	.1000				
264-	GRID	21034	100	.1450	45.0000	.0				
265-	GRID	21039	100	.1450	30.0000	.1000				
266-	GRID	21040	100	.1450	30.0000	.0				
267-	GRID	21045	100	.1450	15.0000	.1000				
268-	GRID	21046	100	.1450	15.0000	.0				
269-	GRID	21051	100	.1450	.0	.1000				
270-	GRID	21052	100	.1450	.0	.0				
271-	GRID	21057		.8150	.0	.1000				
272-	GRID	21058		.8150	.0	.0				
273-	GRID	31009		.6291	.3250	.1000				
274-	GRID	31014		.6700	.3250	.1000				
275-	GRID	31015		.6700	.3250	.0				
276-	GRID	31016		.6500	.3250	.0				
277-	GRID	31021	100	.1550	75.0000	.1000				
278-	GRID	31022	100	.1550	75.0000	.0				
279-	GRID	31027	100	.1550	60.0000	.1000				
280-	GRID	31028	100	.1550	60.0000	.0				
281-	GRID	31033	100	.1550	45.0000	.1000				
282-	GRID	31034	100	.1550	45.0000	.0				
283-	GRID	31039	100	.1550	30.0000	.1000				
284-	GRID	31040	100	.1550	30.0000	.0				
285-	GRID	31045	100	.1550	15.0000	.1000				
286-	GRID	31046	100	.1550	15.0000	.0				
287-	GRID	31051	100	.1550	.0	.1000				
288-	GRID	31052	100	.1550	.0	.0				
289-	GRID	31057		.8250	.0	.1000				
290-	GRID	31058		.8250	.0	.0				
291-	GRID	41009		.6291	.3350	.1000				
292-	GRID	41014		.6700	.3350	.1000				
293-	GRID	41015		.6700	.3350	.0				
294-	GRID	41016		.6500	.3350	.0				
295-	GRID	41021	100	.1650	75.0000	.1000				
296-	GRID	41022	100	.1650	75.0000	.0				
297-	GRID	41027	100	.1650	60.0000	.1000				
298-	GRID	41028	100	.1650	60.0000	.0				
299-	GRID	41033	100	.1650	45.0000	.1000				
300-	GRID	41034	100	.1650	45.0000	.0				

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
301-	GRID	41039	100	.1650	30.0000	.1000				
302-	GRID	41040	100	.1650	30.0000	.0				
303-	GRID	41045	100	.1650	15.0000	.1000				
304-	GRID	41046	100	.1650	15.0000	.0				
305-	GRID	41051	100	.1650	.0	.1000				
306-	GRID	41052	100	.1650	.0	.0				
307-	GRID	41057		.8350	.0	.1000				
308-	GRID	41058		.8350	.0	.0				
309-	GRID	51009		.6291	.3450	.1000				
310-	GRID	51014		.6700	.3450	.1000				
311-	GRID	51015		.6700	.3450	.0				
312-	GRID	51016		.6500	.3450	.0				
313-	GRID	51021	100	.1750	75.0000	.1000				
314-	GRID	51022	100	.1750	75.0000	.0				
315-	GRID	51027	100	.1750	60.0000	.1000				
316-	GRID	51028	100	.1750	60.0000	.0				
317-	GRID	51033	100	.1750	45.0000	.1000				
318-	GRID	51034	100	.1750	45.0000	.0				
319-	GRID	51039	100	.1750	30.0000	.1000				
320-	GRID	51040	100	.1750	30.0000	.0				
321-	GRID	51045	100	.1750	15.0000	.1000				
322-	GRID	51046	100	.1750	15.0000	.0				
323-	GRID	51051	100	.1750	.0	.1000				
324-	GRID	51052	100	.1750	.0	.0				
325-	GRID	51057		.8450	.0	.1000				
326-	GRID	51058		.8450	.0	.0				
327-	GRID	61009		.6291	.3550	.1000				
328-	GRID	61014		.6700	.3550	.1000				
329-	GRID	61015		.6700	.3550	.0				
330-	GRID	61016		.6500	.3550	.0				
331-	GRID	61021	100	.1850	75.0000	.1000				
332-	GRID	61022	100	.1850	75.0000	.0				
333-	GRID	61027	100	.1850	60.0000	.1000				
334-	GRID	61028	100	.1850	60.0000	.0				
335-	GRID	61033	100	.1850	45.0000	.1000				
336-	GRID	61034	100	.1850	45.0000	.0				
337-	GRID	61039	100	.1850	30.0000	.1000				
338-	GRID	61040	100	.1850	30.0000	.0				
339-	GRID	61045	100	.1850	15.0000	.1000				
340-	GRID	61046	100	.1850	15.0000	.0				
341-	GRID	61051	100	.1850	.0	.1000				
342-	GRID	61052	100	.1850	.0	.0				
343-	GRID	61057		.8550	.0	.1000				
344-	GRID	61058		.8550	.0	.0				
345-	GRID	71009		.6291	.3600	.1000				
346-	GRID	71014		.6700	.3600	.1000				
347-	GRID	71015		.6700	.3600	.0				
348-	GRID	71016		.6500	.3600	.0				
349-	GRID	71021	100	.1900	75.0000	.1000				
350-	GRID	71022	100	.1900	75.0000	.0				

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2) OCTOBER 26, 1978 NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
351-	GRID	71027	100	.1900	60.0000	.1000				
352-	GRID	71028	100	.1900	60.0000	.0				
353-	GRID	71033	100	.1900	45.0000	.1000				
354-	GRID	71034	100	.1900	45.0000	.0				
355-	GRID	71039	100	.1900	30.0000	.1000				
356-	GRID	71040	100	.1900	30.0000	.0				
357-	GRID	71045	100	.1900	15.0000	.1000				
358-	GRID	71046	100	.1900	15.0000	.0				
359-	GRID	71051	100	.1900	.0	.1000				
360-	GRID	71052	100	.1900	.0	.0				
361-	GRID	71057		.8600	.0	.1000				
362-	GRID	71058		.8600	.0	.0				
363-	GRID	81009		.6291	.3700	.1000				
364-	GRID	81014		.6700	.3700	.1000				
365-	GRID	81015		.6700	.3700	.0				
366-	GRID	81016		.6500	.3700	.0				
367-	GRID	81021	100	.2000	75.0000	.1000				
368-	GRID	81022	100	.2000	75.0000	.0				
369-	GRID	81027	100	.2000	60.0000	.1000				
370-	GRID	81028	100	.2000	60.0000	.0				
371-	GRID	81033	100	.2000	45.0000	.1000				
372-	GRID	81034	100	.2000	45.0000	.0				
373-	GRID	81039	100	.2000	30.0000	.1000				
374-	GRID	81040	100	.2000	30.0000	.0				
375-	GRID	81045	100	.2000	15.0000	.1000				
376-	GRID	81046	100	.2000	15.0000	.0				
377-	GRID	81051	100	.2000	.0	.1000				
378-	GRID	81052	100	.2000	.0	.0				
379-	GRID	81057		.8700	.0	.1000				
380-	GRID	81058		.8700	.0	.0				
381-	GRID	91009		.6291	.3800	.1000				
382-	GRID	91014		.6700	.3800	.1000				
383-	GRID	91015		.6700	.3800	.0				
384-	GRID	91016		.6500	.3800	.0				
385-	GRID	91021	100	.2100	75.0000	.1000				
386-	GRID	91022	100	.2100	75.0000	.0				
387-	GRID	91027	100	.2100	60.0000	.1000				
388-	GRID	91028	100	.2100	60.0000	.0				
389-	GRID	91033	100	.2100	45.0000	.1000				
390-	GRID	91034	100	.2100	45.0000	.0				
391-	GRID	91039	100	.2100	30.0000	.1000				
392-	GRID	91040	100	.2100	30.0000	.0				
393-	GRID	91045	100	.2100	15.0000	.1000				
394-	GRID	91046	100	.2100	15.0000	.0				
395-	GRID	91051	100	.2100	.0	.1000				
396-	GRID	91052	100	.2100	.0	.0				
397-	GRID	91057		.8800	.0	.1000				
398-	GRID	91058		.8800	.0	.0				
399-	GRID	101009		.6291	.3900	.1000				
400-	GRID	101014		.6700	.3900	.1000				

15
F

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2) OCTOBER 26, 1978 NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
401-	GRID	101015		.6700	.3500	.0				
402-	GRID	101016		.6500	.3500	.0				
403-	GRID	101021	100	.2200	75.0000	.1000				
404-	GRID	101022	100	.2200	75.0000	.0				
405-	GRID	101027	100	.2200	60.0000	.1000				
406-	GRID	101028	100	.2200	60.0000	.0				
407-	GRID	101033	100	.2200	45.0000	.1000				
408-	GRID	101034	100	.2200	45.0000	.0				
409-	GRID	101039	100	.2200	30.0000	.1000				
410-	GRID	101040	100	.2200	30.0000	.0				
411-	GRID	101045	100	.2200	15.0000	.1000				
412-	GRID	101046	100	.2200	15.0000	.0				
413-	GRID	101051	100	.2200	.0	.1000				
414-	GRID	101052	100	.2200	.0	.0				
415-	GRID	101057		.8900	.0	.1000				
416-	GRID	101058		.8900	.0	.0				
417-	GRID	111009		.6291	.4000	.1000				
418-	GRID	111014		.6700	.4000	.1000				
419-	GRID	111015		.6700	.4000	.0				
420-	GRID	111016		.6500	.4000	.0				
421-	GRID	111021	100	.2300	75.0000	.1000				
422-	GRID	111022	100	.2300	75.0000	.0				
423-	GRID	111027	100	.2300	60.0000	.1000				
424-	GRID	111028	100	.2300	60.0000	.0				
425-	GRID	111033	100	.2300	45.0000	.1000				
426-	GRID	111034	100	.2300	45.0000	.0				
427-	GRID	111039	100	.2300	30.0000	.1000				
428-	GRID	111040	100	.2300	30.0000	.0				
429-	GRID	111045	100	.2300	15.0000	.1000				
430-	GRID	111046	100	.2300	15.0000	.0				
431-	GRID	111051	100	.2300	.0	.1000				
432-	GRID	111052	100	.2300	.0	.0				
433-	GRID	111057		.9600	.0	.1000				
434-	GRID	111058		.9600	.0	.0				
435-	GRID	121009		.6291	.4100	.1000				
436-	GRID	121014		.6700	.4100	.1000				
437-	GRID	121015		.6700	.4100	.0				
438-	GRID	121016		.6500	.4100	.0				
439-	GRID	121021	100	.2400	75.0000	.1000				
440-	GRID	121022	100	.2400	75.0000	.0				
441-	GRID	121027	100	.2400	60.0000	.1000				
442-	GRID	121028	100	.2400	60.0000	.0				
443-	GRID	121033	100	.2400	45.0000	.1000				
444-	GRID	121034	100	.2400	45.0000	.0				
445-	GRID	121039	100	.2400	30.0000	.1000				
446-	GRID	121040	100	.2400	30.0000	.0				
447-	GRID	121045	100	.2400	15.0000	.1000				
448-	GRID	121046	100	.2400	15.0000	.0				
449-	GRID	121051	100	.2400	.0	.1000				
450-	GRID	121052	100	.2400	.0	.0				

15
B

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
451-	GRID	121057		.9100	.0	.1000				
452-	GRID	121058		.9100	.0	.0				
453-	GRID	131009		.6291	.4200	.1000				
454-	GRID	131014		.6700	.4200	.1000				
455-	GRID	131015		.6700	.4200	.0				
456-	GRID	131016		.6500	.4200	.0				
457-	GRID	131021	100	.2500	75.0000	.1000				
458-	GRID	131022	100	.2500	75.0000	.0				
459-	GRID	131027	100	.2500	60.0000	.1000				
460-	GRID	131028	100	.2500	60.0000	.0				
461-	GRID	131033	100	.2500	45.0000	.1000				
462-	GRID	131034	100	.2500	45.0000	.0				
463-	GRID	131039	100	.2500	30.0000	.1000				
464-	GRID	131040	100	.2500	30.0000	.0				
465-	GRID	131045	100	.2500	15.0000	.1000				
466-	GRID	131046	100	.2500	15.0000	.0				
467-	GRID	131051	100	.2500	.0	.1000				
468-	GRID	131052	100	.2500	.0	.0				
469-	GRID	131057		.9200	.0	.1000				
470-	GRID	131058		.9200	.0	.0				
471-	MAT1	9	3.+5	1.+5	0.0	1.				
472-	MAT9	1	1.792+6	4.720+5	4.559+5	.0	.0	.0	2.110+7	ELAS001
473-	+LAS001	4.720+5	.0	.0	.0	1.792+6	.0	.0	.0	ELAS002
474-	+LAS002	6.500+5	.0	.0	6.500+5	.0	6.000+5			
475-	MAT9	2	1.792+6	4.640+5	4.640+5	.0	.0	.0	6.065+6	ELAS451
476-	+LAS451	5.305+6	.0	.0	.0	6.609+6	.0	.0	.0	ELAS452
477-	+LAS452	6.250+5	.0	.0	5.407+6	.0	6.250+5			
478-	PWAK	6	9	.01	.01	.01	.01			
479-	PSOLID	1	1	50						
480-	PSOLID	2	1	100						
481-	PSOLID	3	1	0						
482-	PSOLID	11	2	50						
483-	PSOLID	12	2	100						
484-	PSOLID	13	2	0						
485-	PSOLID	21	1	50						
486-	PSOLID	22	1	100						
487-	PSOLID	23	1	0						
488-	PSOLID	31	2	50						
489-	PSOLID	32	2	100						
490-	PSOLID	33	2	0						
491-	PSOLID	41	1	50						
492-	PSOLID	42	1	100						
493-	PSOLID	43	1	0						
494-	PSOLID	51	2	50						
495-	PSOLID	52	2	100						
496-	PSOLID	53	2	0						
497-	PSOLID	61	1	50						
498-	PSOLID	62	1	100						
499-	PSOLID	63	1	0						
500-	PSOLID	71	2	50						

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2) OCTOBER 26, 1978 NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
501-	PSOLID	72	2	100						
502-	PSOLID	73	2	0						
503-	PSOLID	81	1	50						
504-	PSOLID	82	1	100						
505-	PSOLID	83	1	0						
506-	PSOLID	91	2	50						
507-	PSOLID	92	2	100						
508-	PSOLID	93	2	0						
509-	PSOLID	101	1	50						
510-	PSOLID	102	1	100						
511-	PSOLID	103	1	0						
512-	PSOLID	111	2	50						
513-	PSOLID	112	2	100						
514-	PSOLID	113	2	0						
515-	PSOLID	121	1	50						
516-	PSOLID	122	1	100						
517-	PSOLID	123	1	0						
518-	RSPLINE	5001	1.0	1014	11014	123	21014	123	31014	+5001
519-	+5001	123	41014	123	51014	123	61014	123	71014	+5101
520-	+5101	123	81014	123	91014	123	101014	123	111014	+5201
521-	+5201	123	121014	123	131014					
522-	RSPLINE	5002	1.0	1015	11015	12	21015	12	31015	+5002
523-	+5002	12	41015	12	51015	12	61015	12	71015	+5102
524-	+5102	12	81015	12	91015	12	101015	12	111015	+5202
525-	+5202	12	121015	12	131015					
526-	RSPLINE	5003	1.0	1021	11021	123	21021	123	31021	+5003
527-	+5003	123	41021	123	51021	123	61021	123	71021	+5103
528-	+5103	123	81021	123	91021	123	101021	123	111021	+5203
529-	+5203	123	121021	123	131021					
530-	RSPLINE	5004	1.0	1022	11022	12	21022	12	31022	+5004
531-	+5004	12	41022	12	51022	12	61022	12	71022	+5104
532-	+5104	12	81022	12	91022	12	101022	12	111022	+5204
533-	+5204	12	121022	12	131022					
534-	RSPLINE	5005	1.0	1027	11027	123	21027	123	31027	+5005
535-	+5005	123	41027	123	51027	123	61027	123	71027	5105
536-	+5105	123	81027	123	91027	123	101027	123	111027	5205
537-	+5205	123	121027	123	131027					
538-	RSPLINE	5006	1.0	1028	11028	12	21028	12	31028	+5006
539-	+5006	12	41028	12	51028	12	61028	12	71028	5106
540-	+5106	12	81028	12	91028	12	101028	12	111028	5206
541-	+5206	12	121028	12	131028					
542-	RSPLINE	5007	1.0	1033	11033	123	21033	123	31033	+5007
543-	+5007	123	41033	123	51033	123	61033	123	71033	5107
544-	+5107	123	81033	123	91033	123	101033	123	111033	5207
545-	+5207	123	121033	123	131033					
546-	RSPLINE	5008	1.0	1034	11034	12	21034	12	31034	+5008
547-	+5008	12	41034	12	51034	12	61034	12	71034	5108
548-	+5108	12	81034	12	91034	12	101034	12	111034	5208
549-	+5208	12	121034	12	131034					
550-	RSPLINE	5009	1.0	1039	11039	123	21039	123	31039	+5009

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10
551-	+5009	123	41039	123	51039	123	61039	123	71039	5109
552-	+5109	123	81039	123	91039	123	101039	123	111039	5209
553-	+5209	123	121039	123	131039					
554-	RSPLINE	5010	1.0	1040	11040	12	21040	12	31040	+5010
555-	+5010	12	41040	12	51040	12	61040	12	71040	5110
556-	+5110	12	81040	12	91040	12	101040	12	111040	5210
557-	+5210	12	121040	12	131040					
558-	RSPLINE	5011	1.0	1045	11045	123	21045	123	31045	+5011
559-	+5011	123	41045	123	51045	123	61045	123	71045	5111
560-	+5111	123	81045	123	91045	123	101045	123	111045	5211
561-	+5211	123	121045	123	131045					
562-	RSPLINE	5012	1.0	1046	11046	12	21046	12	31046	+5012
563-	+5012	12	41046	12	51046	12	61046	12	71046	5112
564-	+5112	12	81046	12	91046	12	101046	12	111046	5212
565-	+5212	12	121046	12	131046					
566-	RSPLINE	5013	1.0	1051	11051	123	21051	123	31051	+5013
567-	+5013	123	41051	123	51051	123	61051	123	71051	5113
568-	+5113	123	81051	123	91051	123	101051	123	111051	5213
569-	+5213	123	121051	123	131051					
570-	RSPLINE	5014	1.0	1052	11052	12	21052	12	31052	+5014
571-	+5014	12	41052	12	51052	12	61052	12	71052	5114
572-	+5114	12	81052	12	91052	12	101052	12	111052	5214
573-	+5214	12	121052	12	131052					
574-	RSPLINE	5015	1.0	1057	11057	123	21057	123	31057	+5015
575-	+5015	123	41057	123	51057	123	61057	123	71057	5115
576-	+5115	123	81057	123	91057	123	101057	123	111057	5215
577-	+5215	123	121057	123	131057					
578-	RSPLINE	5016	1.0	1058	11058	12	21058	12	31058	+5016
579-	+5016	12	41058	12	51058	12	61058	12	71058	5116
580-	+5116	12	81058	12	91058	12	101058	12	111058	5216
581-	+5216	12	121058	12	131058					
582-	SEQGP	251	1	252	2	1009	19	1014	20	
583-	SEQGP	1015	17	1016	18	1021	15	1022	16	
584-	SEQGP	1027	13	1028	14	1033	11	1034	12	
585-	SEQGP	1039	9	1040	10	1045	7	1046	8	
586-	SEQGP	1051	5	1052	6	1057	3	1058	4	
587-	SEQGP	11009	21	11014	24	11015	23	11016	22	
588-	SEQGP	11021	25	11022	26	11027	27	11028	28	
589-	SEQGP	11033	29	11034	30	11039	31	11040	32	
590-	SEQGP	11045	33	11046	34	11051	35	11052	36	
591-	SEQGP	11057	37	11058	38	21009	39	21014	42	
592-	SEQGP	21015	41	21016	40	21021	43	21022	44	
593-	SEQGP	21027	45	21028	46	21033	47	21034	48	
594-	SEQGP	21039	49	21040	50	21045	51	21046	52	
595-	SEQGP	21051	53	21052	54	21057	55	21058	55	
596-	SEQGP	31009	57	31014	60	31015	59	31016	58	
597-	SEQGP	31021	61	31022	62	31027	63	31028	64	
598-	SEQGP	31033	65	31034	66	31039	67	31040	68	
599-	SEQGP	31045	69	31046	70	31051	71	31052	72	
600-	SEQGP	31057	73	31058	74	41009	75	41014	76	

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
601-	SEQGP	41015	77	41016	78	41021	79	41022	80	
602-	SEQGP	41027	81	41028	82	41033	83	41034	84	
603-	SEQGP	41039	85	41040	86	41045	87	41046	88	
604-	SEQGP	41051	89	41052	90	41057	91	41058	92	
605-	SEQGP	51009	93	51014	94	51015	95	51016	96	
606-	SEQGP	51021	97	51022	98	51027	99	51028	100	
607-	SEQGP	51033	101	51034	102	51039	103	51040	104	
608-	SEQGP	51045	105	51046	106	51051	107	51052	108	
609-	SEQGP	51057	109	51058	110	61009	111	61014	114	
610-	SEQGP	61015	113	61016	112	61021	115	61022	116	
611-	SEQGP	61027	117	61028	118	61033	119	61034	120	
612-	SEQGP	61039	121	61040	122	61045	123	61046	124	
613-	SEQGP	61051	125	61052	126	61057	127	61058	128	
614-	SEQGP	71009	129	71014	132	71015	131	71016	130	
615-	SEQGP	71021	133	71022	134	71027	135	71028	136	
616-	SEQGP	71033	137	71034	138	71039	139	71040	140	
617-	SEQGP	71045	141	71046	142	71051	143	71052	144	
618-	SEQGP	71057	145	71058	146	81009	147	81014	150	
619-	SEQGP	81015	149	81016	148	81021	151	81022	152	
620-	SEQGP	81027	153	81028	154	81033	155	81034	156	
621-	SEQGP	81039	157	81040	158	81045	159	81046	160	
622-	SEQGP	81051	161	81052	162	81057	163	81058	164	
623-	SEQGP	91009	165	91014	168	91015	167	91016	166	
624-	SEQGP	91021	169	91022	170	91027	171	91028	172	
625-	SEQGP	91033	173	91034	174	91039	175	91040	176	
626-	SEQGP	91045	177	91046	178	91051	179	91052	180	
627-	SEQGP	91057	181	91058	182	101009	183	101014	186	
628-	SEQGP	101015	185	101016	184	101021	187	101022	188	
629-	SEQGP	101027	189	101028	190	101033	191	101034	192	
630-	SEQGP	101039	193	101040	194	101045	195	101046	196	
631-	SEQGP	101051	197	101052	198	101057	199	101058	200	
632-	SEQGP	111009	201	111014	204	111015	203	111016	202	
633-	SEQGP	111021	205	111022	206	111027	207	111028	208	
634-	SEQGP	111033	209	111034	210	111039	211	111040	212	
635-	SEQGP	111045	213	111046	214	111051	215	111052	216	
636-	SEQGP	111057	217	111058	218	121009	219	121014	226	
637-	SEQGP	121015	223	121016	220	121021	227	121022	228	
638-	SEQGP	121027	231	121028	232	121033	235	121034	236	
639-	SEQGP	121039	239	121040	240	121045	243	121046	244	
640-	SEQGP	121051	247	121052	248	121057	249	121058	250	
641-	SEQGP	131009	221	131014	224	131015	225	131016	222	
642-	SEQGP	131021	229	131022	230	131027	233	131028	234	
643-	SEQGP	131033	237	131034	238	131039	241	131040	242	
644-	SEQGP	131045	245	131046	246	131051	251	131052	252	
645-	SEQGP	131057	253	131058	254					
646-	SPC	1	1014	1	-4.34E-5	1014	2	-1.08E-4		
647-	SPC	1	1014	3	1.52E-6					
648-	SPC	1	1015	1	-2.10E-5	1015	2	-4.14E-5		
649-	SPC	1	1021	1	-9.07E-5	1021	2	-2.30E-4		
650-	SPC	1	1021	3	1.45E-6					

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
651-	SPC	1	1022	1	-7.09E-5	1022	2	-2.08E-4		
652-	SPC	1	1027	1	-1.74E-4	1027	2	-3.89E-4		
653-	SPC	1	1027	3	7.22E-7					
654-	SPC	1	1028	1	-1.73E-4	1028	2	-3.75E-4		
655-	SPC	1	1033	1	-2.74E-4	1033	2	-5.04E-4		
656-	SPC	1	1033	3	-1.03E-6					
657-	SPC	1	1034	1	-2.78E-4	1034	2	-4.98E-4		
658-	SPC	1	1039	1	-3.85E-4	1039	2	-5.85E-4		
659-	SPC	1	1039	3	-2.50E-6					
660-	SPC	1	1040	1	-3.92E-4	1040	2	-5.82E-4		
661-	SPC	1	1045	1	-4.91E-4	1045	2	-6.30E-4		
662-	SPC	1	1045	3	-3.30E-6					
663-	SPC	1	1046	1	-5.00E-4	1046	2	-6.28E-4		
664-	SPC	1	1051	1	-5.81E-4	1051	2	-6.45E-4		
665-	SPC	1	1051	3	-3.26E-6					
666-	SPC	1	1052	1	-5.88E-4	1052	2	-6.43E-4		
667-	SPC	1	1057	1	-1.00E-3	1057	2	-6.60E-4		
668-	SPC	1	1057	3	-3.67E-6					
669-	SPC	1	1058	1	-1.01E-3	1058	2	-6.59E-4		
670-	SPC	1	131014	1	4.48E-5	131014	2	-1.52E-4		
671-	SPC	1	131014	3	5.80E-6					
672-	SPC	1	131015	1	2.42E-5	131015	2	-1.18E-4		
673-	SPC	1	131021	1	5.99E-5	131021	2	-3.58E-4		
674-	SPC	1	131021	3	6.81E-6					
675-	SPC	1	131022	1	4.95E-5	131022	2	-3.33E-4		
676-	SPC	1	131027	1	1.57E-5	131027	2	-5.43E-4		
677-	SPC	1	131027	3	1.73E-6					
678-	SPC	1	131028	1	7.58E-6	131028	2	-5.30E-4		
679-	SPC	1	131033	1	-9.33E-5	131033	2	-7.19E-4		
680-	SPC	1	131033	3	-4.84E-6					
681-	SPC	1	131034	1	-1.01E-4	131034	2	-7.11E-4		
682-	SPC	1	131039	1	-2.43E-4	131039	2	-8.51E-4		
683-	SPC	1	131039	3	-1.08E-5					
684-	SPC	1	131040	1	-2.51E-4	131040	2	-8.40E-4		
685-	SPC	1	131045	1	-4.12E-4	131045	2	-9.31E-4		
686-	SPC	1	131045	3	-1.43E-5					
687-	SPC	1	131046	1	-4.21E-4	131046	2	-9.27E-4		
688-	SPC	1	131051	1	-5.31E-4	131051	2	-9.60E-4		
689-	SPC	1	131051	3	-1.51E-5					
690-	SPC	1	131052	1	-5.88E-4	131052	2	-9.57E-4		
691-	SPC	1	131057	1	-1.00E-3	131057	2	-9.78E-4		
692-	SPC	1	131057	3	-1.38E-5					
693-	SPC	1	131058	1	-1.01E-3	131058	2	-9.74E-4		
694-	SPC	2	1014	1	-1.18E-5	1014	2	-4.11E-6		
695-	SPC	2	1014	3	2.40E-6					
696-	SPC	2	1015	1	-5.59E-6	1015	2	4.05E-6		
697-	SPC	2	1021	1	-2.32E-5	1021	2	-1.18E-5		
698-	SPC	2	1021	3	2.41E-6					
699-	SPC	2	1022	1	-1.92E-5	1022	2	-8.58E-6		
700-	SPC	2	1027	1	-4.17E-5	1027	2	-3.17E-5		

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
701-	SPC	2	1027	3	1.85E-6					
702-	SPC	2	1028	1	-3.94E-5	1028	2	-2.99E-5		
703-	SPC	2	1033	1	-6.65E-5	1033	2	-4.94E-5		
704-	SPC	2	1033	3	1.27E-6					
705-	SPC	2	1034	1	-6.56E-5	1034	2	-4.86E-5		
706-	SPC	2	1039	1	-1.00E-4	1039	2	-6.48E-5		
707-	SPC	2	1039	3	8.75E-7					
708-	SPC	2	1040	1	-1.01E-4	1040	2	-6.45E-5		
709-	SPC	2	1045	1	-1.40E-4	1045	2	-7.23E-5		
710-	SPC	2	1045	3	7.40E-7					
711-	SPC	2	1046	1	-1.40E-4	1046	2	-7.21E-5		
712-	SPC	2	1051	1	-1.96E-4	1051	2	-7.18E-5		
713-	SPC	2	1051	3	8.69E-7					
714-	SPC	2	1052	1	-1.97E-4	1052	2	-7.15E-5		
715-	SPC	2	1057	1	-4.91E-4	1057	2	-4.12E-5		
716-	SPC	2	1057	3	2.71E-6					
717-	SPC	2	1058	1	-4.94E-4	1058	2	-4.10E-5		
718-	SPC	2	131014	1	1.16E-5	131014	2	-1.70E-5		
719-	SPC	2	131014	3	-1.76E-6					
720-	SPC	2	131015	1	5.76E-6	131015	2	-1.69E-5		
721-	SPC	2	131021	1	2.04E-5	131021	2	-5.14E-5		
722-	SPC	2	131021	3	-1.67E-6					
723-	SPC	2	131022	1	1.73E-5	131022	2	-4.88E-5		
724-	SPC	2	131027	1	1.76E-5	131027	2	-9.07E-5		
725-	SPC	2	131027	3	-1.76E-6					
726-	SPC	2	131028	1	1.57E-5	131028	2	-8.88E-5		
727-	SPC	2	131033	1	-5.79E-6	131033	2	-1.40E-4		
728-	SPC	2	131033	3	-2.22E-6					
729-	SPC	2	131034	1	-6.88E-6	131034	2	-1.39E-4		
730-	SPC	2	131039	1	-5.00E-5	131039	2	-1.89E-4		
731-	SPC	2	131039	3	-7.85E-6					
732-	SPC	2	131040	1	-5.16E-5	131040	2	-1.89E-4		
733-	SPC	2	131045	1	-1.21E-4	131045	2	-2.30E-4		
734-	SPC	2	131045	3	-3.37E-6					
735-	SPC	2	131046	1	-1.22E-4	131046	2	-2.30E-4		
736-	SPC	2	131051	1	-2.00E-4	131051	2	-2.51E-4		
737-	SPC	2	131051	3	-3.55E-6					
738-	SPC	2	131052	1	-2.01E-4	131052	2	-2.52E-4		
739-	SPC	2	131057	1	-4.90E-4	131057	2	-2.83E-4		
740-	SPC	2	131057	3	-3.84E-6					
741-	SPC	2	131058	1	-4.92E-4	131058	2	-2.83E-4		
742-	SPC1	19	3	1015	1022	1028	1034	1040	1046	
743-	SPC1	19	3	1052	1058					
744-	SPC1	19	3	11015	11022	11028	11034	11040	11046	
745-	SPC1	19	3	11052	11058					
746-	SPC1	19	3	21015	21022	21028	21034	21040	21046	
747-	SPC1	19	3	21052	21058					
748-	SPC1	19	3	31015	31022	31028	31034	31040	31046	
749-	SPC1	19	3	31052	31058					
750-	SPC1	19	3	41015	41022	41028	41034	41040	41046	

COMPOSITE BRACKET MODEL C2.2 (STACK SEG 2, PHASE 2)   OCTOBER 26, 1976   NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
751-	SPC1	19	3	41052	41058					
752-	SPC1	19	3	51015	51022	51028	51034	51040	51045	
753-	SPC1	19	3	51052	51058					
754-	SPC1	19	3	61015	61022	61028	61034	61040	61046	
755-	SPC1	19	3	61052	61058					
756-	SPC1	19	3	71015	71022	71028	71034	71040	71046	
757-	SPC1	19	3	71052	71058					
758-	SPC1	19	3	81015	81022	81028	81034	81040	81046	
759-	SPC1	19	3	81052	81058					
760-	SPC1	19	3	91015	91022	91028	91034	91040	91046	
761-	SPC1	19	3	91052	91058					
762-	SPC1	19	3	101015	101022	101028	101034	101040	101046	
763-	SPC1	19	3	101052	101058					
764-	SPC1	19	3	111015	111022	111028	111034	111040	111046	
765-	SPC1	19	3	111052	111058					
766-	SPC1	19	3	121015	121022	121028	121034	121040	121046	
767-	SPC1	19	3	121052	121058					
768-	SPC1	19	3	131015	131022	131028	131034	131040	131046	
769-	SPC1	19	3	131052	131058					
770-	SPC1	19	123	1009	1016					
771-	SPC1	19	123	11009	11016					
772-	SPC1	19	123	21009	21016					
773-	SPC1	19	123	31009	31016					
774-	SPC1	19	123	41009	41016					
775-	SPC1	19	123	51009	51016					
776-	SPC1	19	123	61009	61016					
777-	SPC1	19	123	71009	71016					
778-	SPC1	19	123	81009	81016					
779-	SPC1	19	123	91009	91016					
780-	SPC1	19	123	101009	101016					
781-	SPC1	19	123	111009	111016					
782-	SPC1	19	123	121009	121016					
783-	SPC1	19	123	131009	131016					
784-	SPCADD	20	1	19						
785-	SPCADD	21	2	19						
	ENDDATA									

TOTAL COUNT= 785

```
COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)                 OCTOBER 26, 1978   NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS


   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
  1  BEGIN     NO. 24 LINEAR STATIC ANALYSIS 7 JUN 1976 $
  2  PARAM     //DIAGON//47 $
  3  FILE      GM=SAVE / KNN=SAVE / MNN=SAVE $
  4  FILE      QG=APPEND/PGG=APPEND/UGV=APPEND $
  5  SETVAL    //V,N,CARDNO/0 $
  6  SETVAL    //V,N,MODS/1/V,N,NOMOD/-1 $
  7  SETVAL    //V,N,NOKGGX/1 $
  8  SETVAL    //V,N,NOMGGX/1 $
  9  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/S,N,LUSET/0/S,N,
               NOGPDT $
 10  COND      ERROR,NOGPDT $
 11  GP2       GEOM2,EQEXIN/ECT $
 12  PARAML    PCDB//PRES////V,N,JUMPPLOT $
 13  COND      P1,JUMPPLOT $
 14  PARAM     //DIAGOFF//47 $
 15  PLTHBDY   GEOM2,ECT,EPT,SIL,EQEXIN,BGPDT/PECT,PSIL,PEQIN,PBGPDT/S,N,
               NHBDY/C,Y,MESH=NO $
 16  EQUIV     EQEXIN,PEQIN/NHBDY/ECT,PECT/NHBDY/BGPDT,PBGPDT/NHBDY/ SIL,PSIL/
               NHBDY $
 17  PLTSET    PCDB,PEQIN,PECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,NSIL/   S,N,
               JUMPPLOT $
 18  CHKPNT    PLTPAR,GPSETS,ELSETS $
 19  PRTMSG    PLTSETX// $
 20  SETVAL    //V,N,PLTFLG/1 / V,N,PFILE/0 $
 21  COND      P1,JUMPPLOT $
 22  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,PBGPDT,PEQIN,PSIL,,ECT,,/PLOTX1/
               NSIL/LUSET/S,N,JUMPPLOT/S,N,PLTFLG/S,N,PFILE $
 23  PRTMSG    PLOTX1//$
 24  LABEL     P1 $
 25  PARAM     //DIAGON//47 $
 26  GP3       GEOM3,EQEXIN,GEOM2/SLT,ETT/0/V,N,NOGRAV/0 $
 27  COND      LMODS,MODS $
 28  TA1,      ,ECT,EPT,BGPDT,SIL,ETT,CSTM/EST,,GEI,GPECT,/V,N,LUSET/0/   S,N,
               NOSIMP/1/S,N,NOGENL/S,N,GENEL $
 29  COND      LSKPEMG,NOSIMP $
 30  PARAM     //DIAGOFF//47 $
 31  EMG       EST,CSTM,MPT,DIT,GEOM2,,,/KELM,KDICT,MELM,MDICT,,/S,N,NOKGGX/
               S,N,NOMGGX/0///C,Y,COUPMASS $
 32  CHKPNT    KELM,KDICT $
 33  CHKPNT    MELM,MDICT $
 34  PARAM     //DIAGON//47 $
 35  PURGE     KGGX/NOKGGX $
 36  COND      LEMAK,NOKGGX $
 37  EMA       GPECT,KDICT,KELM,BGPDT,SIL,CSTM/KGGX, $
 38  LABEL     LEMAK $
 39  PURGE     MGGX/NOMGGX $
 40  COND      LMODS,NOMGGX $
 41  EMA       GPECT,MDICT,MELM,BGPDT,SIL,CSTM/MGGX,/-1/C,Y,WTMASS=1. $
 42  LABEL     LMODS $
```

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)   OCTOBER 26, 1978   NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

A DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1=	251-1	251-2	251-3	252-1	252-2	252-3				

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)   OCTOBER 26, 1978   NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

S DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	
1001=	121051-4	121051-5	121051-6	121052-3	121052-4	121052-5	121052-6	121057-4	121057-5	121057-6 =	1010
1011=	121058-3	121058-4	121058-5	121058-6	131051-1	131051-2	131051-3	131051-4	131051-5	131051-6 =	1020
1021=	131052-1	131052-2	131052-3	131052-4	131052-5	131052-6	131057-1	131057-2	131057-3	131057-4 =	1030
1031=	131057-5	131057-6	131058-1	131058-2	131058-3	131058-4	131058-5	131058-6			

*** USER INFORMATION MESSAGE 3035 FOR DATA BLOCK KLL

LOAD SEQ. NO.	EPSILON	STRAIN ENERGY	EPSILONS LARGER THAN .001 ARE FLAGGED WITH ASTERISKS
2	-1.2620180E-16	4.3965531E-01	

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2) OCTOBER 26, 1978 NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

UNIFORM PULL, RSPLINE ELEMS USED FOR PARABOLIC DISTN SUBCASE 1

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
251	G	-5.844978E-04	-6.445420E-04	-3.258853E-06	0.0	0.0	0.0
252	G	-5.845015E-04	-6.434573E-04	-[illegible]145288E-09	0.0	0.0	0.0
1009	G	0.0	0.0	0.0	0.0	0.0	0.0
1014	G	-4.340000E-05	-1.080000E-04	1.519999E-06	0.0	0.0	0.0
1015	G	-2.100000E-05	-4.140000E-05	0.0	0.0	0.0	0.0
1016	G	0.0	0.0	0.0	0.0	0.0	0.0
1021	G	-9.069999E-05	-2.360000E-04	1.949999E-06	0.0	0.0	0.0
1022	G	-7.689999E-05	-2.060000E-04	0.0	0.0	0.0	0.0
1027	G	-1.740000E-04	-3.885999E-04	7.220000E-07	0.0	0.0	0.0
1028	G	-1.710000E-04	-3.749998E-04	0.0	0.0	0.0	0.0
1033	G	-2.740000E-04	-5.039999E-04	-1.029999E-06	0.0	0.0	0.0
1034	G	-2.779998E-04	-4.979998E-04	0.0	0.0	0.0	0.0
1039	G	-3.849999E-04	-5.849998E-04	-2.500000E-06	0.0	0.0	0.0
1040	G	-3.920000E-04	-5.819998E-04	0.0	0.0	0.0	0.0
1045	G	-4.909998E-04	-6.299999E-04	-3.300000E-06	0.0	0.0	0.0
1046	G	-4.999998E-04	-6.279999E-04	0.0	0.0	0.0	0.0
1051	G	-5.809998E-04	-6.449998E-04	-3.259999E-06	0.0	0.0	0.0
1052	G	-5.879998E-04	-6.429998E-04	0.0	0.0	0.0	0.0
1057	G	-9.999999E-04	-6.599999E-04	-3.669999E-06	0.0	0.0	0.0
1058	G	-1.010000E-03	-6.589999E-04	0.0	0.0	0.0	0.0
11009	G	0.0	0.0	0.0	0.0	0.0	0.0
11014	G	-4.179687E-05	-1.115200E-04	1.597752E-06	0.0	0.0	0.0
11015	G	-2.017844E-05	-4.736798E-05	0.0	0.0	0.0	0.0
11016	G	0.0	0.0	0.0	0.0	0.0	0.0
11021	G	-8.922460E-05	-2.429271E-04	2.038335E-06	0.0	0.0	0.0
11022	G	-7.796641E-05	-2.154978E-04	0.0	0.0	0.0	0.0
11027	G	-1.717426E-04	-3.938612E-04	7.403216E-07	0.0	0.0	0.0
11028	G	-1.691440E-04	-3.802238E-04	0.0	0.0	0.0	0.0
11033	G	-2.717758E-04	-5.089680E-04	-1.099251E-06	0.0	0.0	0.0
11034	G	-2.758952E-04	-5.029840E-04	0.0	0.0	0.0	0.0
11039	G	-3.829554E-04	-5.901444E-04	-2.647225E-06	0.0	0.0	0.0
11040	G	-3.899666E-04	-5.871035E-04	0.0	0.0	0.0	0.0
11045	G	-4.896591E-04	-6.354963E-04	-3.499937E-06	0.0	0.0	0.0
11046	G	-4.986282E-04	-6.334516E-04	0.0	0.0	0.0	0.0
11051	G	-5.809995E-04	-6.507251E-04	-3.47[illegible]765E-06	0.0	0.0	0.0
11052	G	-5.879996E-04	-6.487069E-04	0.0	0.0	0.0	0.0
11057	G	-9.999997E-04	-6.657434E-04	-3.850488E-06	0.0	0.0	0.0
11058	G	-1.010000E-03	-6.647252E-04	0.0	0.0	0.0	0.0
21009	G	0.0	0.0	0.0	0.0	0.0	0.0
21014	G	-3.734874E-05	-1.150400E-04	1.813842E-06	0.0	0.0	0.0
21015	G	-1.789890E-05	-5.333601E-05	0.0	0.0	0.0	0.0
21016	G	0.0	0.0	0.0	0.0	0.0	0.0
21021	G	-8.223308E-05	-2.513321E-04	2.283435E-06	0.0	0.0	0.0
21022	G	-7.216063E-05	-2.243010E-04	0.0	0.0	0.0	0.0
21027	G	-1.627451E-04	-4.026140E-04	7.911573E-07	0.0	0.0	0.0
21028	G	-1.608035E-04	-3.891520E-04	0.0	0.0	0.0	0.0
21033	G	-2.631699E-04	-5.203178E-04	-1.291394E-06	0.0	0.0	0.0
21034	G	-2.675012E-04	-5.142584E-04	0.0	0.0	0.0	0.0
21039	G	-3.760508E-04	-6.037075E-04	-3.055725E-06	0.0	0.0	0.0
21040	G	-3.831089E-04	-6.005641E-04	0.0	0.0	0.0	0.0

UNIFORM PULL, RSPLINE ELEMS USED FOR PARABOLIC DISTN   SUBCASE 1

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
251	G	0.0	0.0	0.0	-1.952558E+00	-1.066108E-02	1.464418E+00
252	G	0.0	0.0	0.0	-1.952558E+00	-3.331241E-03	-1.464418E+00
1009	G	6.924487E+00	1.019647E+00	2.815616E-01	0.0	0.0	0.0
1014	G	-8.593826E-01	-1.175164E+00	-2.533222E+00	-3.237706E-02	0.0	6.045821E-02
1015	G	8.566856E-01	6.137734E-01	6.203419E-01	0.0	0.0	4.824886E-02
1016	G	6.592603E+00	9.519511E-01	3.280184E-01	0.0	0.0	0.0
1021	G	-3.235127E+00	-8.454262E-01	-1.633750E+00	-1.733587E-02	4.645167E-03	6.325388E-02
1022	G	-3.380303E+00	-1.922837E-01	4.215069E-01	0.0	0.0	7.755738E-02
1027	G	-3.011029E+00	-1.374071E-01	-9.160728E-01	-4.714608E-03	2.722014E-03	6.984508E-02
1028	G	-3.560829E+00	5.264490E-01	1.963463E-01	0.0	0.0	8.924669E-02
1033	G	-1.349674E+00	3.083801E-01	-3.575627E-01	1.172074E-04	-1.172114E-04	4.642190E-02
1034	G	-1.968568E+00	1.031521E+00	5.658605E-02	0.0	0.0	6.803632E-02
1039	G	-8.670491E-01	6.477575E-01	-1.279674E-01	8.163157E-05	-1.413865E-04	4.281126E-02
1040	G	-1.058969E+00	1.011467E+00	-1.966605E-02	0.0	0.0	5.433124E-02
1045	G	-4.623004E-01	8.597102E-01	8.227881E-04	-2.172637E-05	8.108500E-05	3.976006E-02
1046	G	-7.665056E-01	1.459807E+00	-5.918415E-02	0.0	0.0	5.565664E-02
1051	G	4.264554E-01	-3.800972E+01	-9.068453E-02	0.0	-1.341779E-03	1.549953E+00
1052	G	-1.011030E-01	4.082672E+01	-1.035634E-01	0.0	3.664922E-03	-1.360913E+00
1057	G	2.332221E-01	-2.308340E+00	3.444882E-02	0.0	-5.582164E-04	1.097604E-02
1058	G	-9.753257E-02	-1.843628E+00	-1.936529E-01	0.0	0.0	2.314554E-02
11009	G	6.993392E+00	7.309643E-01	1.483333E-03	0.0	0.0	0.0
11015	G	0.0	0.0	6.903341E-01	0.0	0.0	0.0
11016	G	7.202234E+00	6.170155E-01	8.820634E-01	0.0	0.0	0.0
11022	G	0.0	0.0	6.801376E-01	0.0	0.0	0.0
11028	G	0.0	0.0	4.007128E-01	0.0	0.0	0.0
11034	G	0.0	0.0	2.157919E-01	0.0	0.0	0.0
11040	G	0.0	0.0	9.175564E-02	0.0	0.0	0.0
11046	G	0.0	0.0	1.476735E-02	0.0	0.0	0.0
11052	G	0.0	0.0	-4.483046E-02	0.0	0.0	0.0
11058	G	0.0	0.0	-2.630437E-02	0.0	0.0	0.0
21009	G	6.111633E+00	7.265769E-01	-2.236578E-02	0.0	0.0	0.0
21015	G	0.0	0.0	6.117893E-01	0.0	0.0	0.0
21016	G	6.269170E+00	8.444965E-01	8.104619E-01	0.0	0.0	0.0
21022	G	0.0	0.0	6.260102E-01	0.0	0.0	0.0
21028	G	0.0	0.0	3.735201E-01	0.0	0.0	0.0
21034	G	0.0	0.0	2.057077E-01	0.0	0.0	0.0
21040	G	0.0	0.0	9.257490E-02	0.0	0.0	0.0
21046	G	0.0	0.0	2.204135E-02	0.0	0.0	0.0
21052	G	0.0	0.0	-2.355865E-02	0.0	0.0	0.0
21058	G	0.0	0.0	-1.128678E-02	0.0	0.0	0.0
31009	G	5.283076E+00	7.100318E-01	-1.544963E-02	0.0	0.0	0.0
31015	G	0.0	0.0	4.866815E-01	0.0	0.0	0.0
31016	G	5.391358E+00	6.616674E-01	5.686608E-01	0.0	0.0	0.0
31022	G	0.0	0.0	4.638783E-01	0.0	0.0	0.0
31028	G	0.0	0.0	2.639427E-01	0.0	0.0	0.0
31034	G	0.0	0.0	1.425324E-01	0.0	0.0	0.0
31040	G	0.0	0.0	6.702632E-02	0.0	0.0	0.0
31046	G	0.0	0.0	1.972527E-02	0.0	0.0	0.0
31052	G	0.0	0.0	4.407633E-03	0.0	0.0	0.0
31058	G	0.0	0.0	9.928256E-03	0.0	0.0	0.0

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

OCTOBER 26, 1976 NASTRAN 3/11/76 63

UNIFORM PULL, RSPLINE ELEMS USED FOR PARABOLIC DISTN

SUBCASE 1

S T R E S S E S   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	SA1 / SB1	SA2 / SB2	SA3 / SB3	SA4 / SB4	AXIAL STRESS	SA-MAX / SB-MAX	SA-MIN / SB-MIN	M.S.-T / M.S.-C
1	0.0	0.0	0.0	0.0	1.399233E+01	1.399233E+01	1.399233E+01	
	0.0	0.0	0.0	0.0		1.399233E+01	1.399233E+01	
2	0.0	0.0	0.0	0.0	-1.399233E+01	-1.399233E+01	-1.399233E+01	
	0.0	0.0	0.0	0.0		-1.399233E+01	-1.399233E+01	
3	0.0	0.0	0.0	0.0	-9.773125E+00	-9.773125E+00	-9.773125E+00	
	0.0	0.0	0.0	0.0		-9.773125E+00	-9.773125E+00	

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

OCTOBER 26, 1976 NASTRAN 3/11/76

UNIFORM PULL, RSPLINE ELEMS USED FOR PARABOLIC DISTN

SUBCASE 1

S T R E S S E S   I N   H E X A H E D R O N   S O L I D   E L E M E N T S   (H E X A 1)

ELEMENT-ID	CORNER GRID-ID		NORMAL		SHEAR		PRINCIPAL	DIR. COSINES -A- -B- -C-	MEAN PRESSURE	OCTAHEDRAL SHEAR
			------CENTER AND	CORNER	POINT STRESSES---------					
1012	90+MAT CS 8 GP									
	CENTER	X	-9.100190E+02	XY	1.559015E+03	A	-3.319600E+02	LX-0.59-0.07-0.81	7.829570E+03	1.010516E+04
		Y	-2.199958E+04	YZ	1.253672E+02	B	-2.211453E+04	LY-0.04 1.00-0.06		
		Z	-5.791084E+02	ZX	-3.608848E+02	C	-1.042779E+03	LZ 0.81-0.01-0.59		
	1016	X	-4.998108E+02	XY	1.420266E+03	A	-1.550512E+02	LX 0.78-0.07-0.65	7.731273E+03	1.030702E+04
		Y	-2.222102E+04	YZ	1.269756E+02	B	-2.238375E+04	LY 0.04 1.00-0.05		
		Z	-4.087300E+02	ZX	-2.957654E+02	C	-7.350159E+02	LZ-0.65-0.01-0.78		
	1009	X	-4.982260E+02	XY	1.696763E+03	A	-1.116004E+02	LX 0.77-0.08-0.63	7.703969E+03	1.040436E+04
		Y	-2.230143E+04	YZ	1.279684E+02	B	-2.249339E+04	LY 0.06 1.00-0.05		
		Z	-4.922507E+02	ZX	-3.223108E+02	C	-7.409760E+02	LZ-0.63-0.01-0.77		
	1014	X	-1.123746E+03	XY	1.687771E+03	A	-3.013708E+02	LX-0.59-0.08-0.84	8.091838E+03	1.030231E+04
		Y	-2.251950E+04	YZ	1.299557E+02	B	-2.265305E+04	LY-0.04 1.00-0.07		
		Z	-6.322640E+02	ZX	-4.010287E+02	C	-1.261093E+03	LZ 0.84-0.01-0.54		
	1015	X	-1.559011E+03	XY	1.511280E+03	A	-5.869417E+02	LX-0.38-0.07-0.92	8.261082E+03	1.013357E+04
		Y	-2.248395E+04	YZ	1.285228E+02	B	-2.257578E+04	LY-0.02 1.00-0.06		
		Z	-7.402883E+02	ZX	-3.745587E+02	C	-1.610525E+03	LZ 0.92-0.01-0.38		
	11016	X	-4.753914E+02	XY	1.420220E+03	A	-1.333475E+02	LX 0.78-0.07-0.65	7.430328E+03	9.911801E+03
		Y	-2.134659E+04	YZ	1.207664E+02	B	-2.144373E+04	LY 0.05 1.00-0.05		
		Z	-4.690139E+02	ZX	-2.957049E+02	C	-7.139141E+02	LZ-0.65-0.01-0.78		
	11009	X	-4.796013E+02	XY	1.696763E+03	A	-8.980227E+01	LX 0.77-0.08-0.63	7.495273E+03	1.002624E+04
		Y	-2.153287E+04	YZ	1.219025E+02	B	-2.186977E+04	LY 0.06 1.00-0.06		
		Z	-4.733528E+02	ZX	-3.223178E+02	C	-7.262054E+02	LZ-0.63-0.01-0.78		
	11014	X	-1.104632E+03	XY	1.687771E+03	A	-3.601965E+02	LX-0.54-0.08-0.84	7.802523E+03	9.924512E+03
		Y	-2.169055E+04	YZ	1.235418E+02	B	-2.182918E+04	LY-0.04 1.00-0.07		
		Z	-6.121831E+02	ZX	-4.016287E+02	C	-1.218217E+03	LZ 0.84-0.01-0.54		
	11015	X	-1.539313E+03	XY	1.511280E+03	A	-5.697587E+02	LX-0.38-0.07-0.92	7.959260E+03	9.738055E+03
		Y	-2.161981E+04	YZ	1.223427E+02	B	-2.177956E+04	LY-0.02 1.00-0.07		
		Z	-7.194405E+02	ZX	-3.745587E+02	C	-1.593295E+03	LZ 0.92-0.01-0.39		
2005	100+MAT CS 8 GP									
	CENTER	X	-1.490395E+03	XY	2.822325E+03	A	-5.971555E+02	LX-0.45-0.14-0.88	7.606081E+03	9.507863E+03
		Y	-2.203865E+04	YZ	6.440566E+01	B	-2.106253E+04	LY-0.06 0.99-0.13		
		Z	-6.891755E+02	ZX	-2.875201E+02	C	-1.224524E+03	LZ 0.89-0.01-0.46		
	1015	X	-2.766535E+03	XY	3.208167E+03	A	-9.489685E+02	LX-0.28-0.15-0.95	9.150227E+03	1.080155E+04
		Y	-2.365422E+04	YZ	6.578701E+01	B	-2.412772E+04	LY-0.04 0.99-0.14		
		Z	-1.072422E+03	ZX	-4.032781E+02	C	-2.398308E+03	LZ 0.96-0.01-0.28		

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2) OCTOBER 26, 1978 NASTRAN 3/11/78
ONE STRIP ALONG SYM LINE WITH 13 UNEQUAL LAYERS

UNIFORM PULL. RSPLINE ELEMS USED FOR PARABOLIC DISTN SUBCASE 1

E L E M E N T   S T R A I N   E N E R G I E S

ELEMENT-TYPE = HEXA * TOTAL ENERGY OF ALL ELEMENTS IN PROBLEM = 1.183829E-02
SUBCASE 1 TOTAL ENERGY OF ALL ELEMENTS IN SET -1 = 1.183829E-02

ELEMENT-ID	STRAIN-ENERGY	PERCENT OF TOTAL
1012	4.150526E-04	3.5060
2005	5.630199E-04	4.7559
2010	4.056862E-04	3.4268
2015	2.254115E-04	1.9041
2020	1.466679E-04	1.2389
2025	9.280012E-05	0.7839
2030	5.283947E-05	0.4463
3005	2.148253E-04	1.8147
11012	1.625593E-04	1.3732
12005	2.660607E-04	2.2475
12010	2.171157E-04	1.8340
12015	1.173465E-04	0.9912
12020	6.841439E-05	0.5779
12025	3.392858E-05	0.2866
12030	1.182798E-05	0.0999
13005	4.420405E-05	0.3734
21012	2.921987E-04	2.4683
22005	3.399721E-04	2.8718
22010	1.975630E-04	1.6688
22015	7.668945E-05	0.6478
22020	2.984335E-05	0.2521
22025	9.402895E-06	0.0794
22030	3.832377E-06	0.0324
23005	1.544028E-05	0.1304
31012	1.150184E-04	0.9716
32005	1.561266E-04	1.3188
32010	9.670311E-05	0.8169
32015	3.475702E-05	0.2936
32020	9.827748E-06	0.0830
32025	7.840542E-07	0.0066
32030	3.754735E-06	0.0317
33005	1.914875E-05	0.1618
41012	1.376333E-04	1.1626
42005	1.437058E-04	1.2139
42010	7.224940E-05	0.6103
42015	1.939065E-05	0.1638
42020	3.676816E-06	0.0311
42025	4.236657E-06	0.0358
42030	1.596409E-05	0.1349
43005	7.121517E-05	0.6016
51012	8.903682E-05	0.7521
52005	1.042352E-04	0.8805
52010	4.994453E-05	0.4219
52015	1.275543E-05	0.1077
52020	1.890377E-06	0.0160
52025	4.712669E-06	0.0398
52030	1.756898E-05	0.1484
53005	8.419911E-05	0.7112
61012	4.831034E-05	0.4081

COMPOSITE BRACKET MODEL C2.2 (STACK SEQ 2, PHASE 2)   OCTOBER 26, 1976   NASTRAN 3/11/76
ONE STRIP ALONG SYM LINE WITH 15 UNEQUAL LAYERS

CLOCKWISE COUPLE, HSPLINE ELPS USED FOR PARAB DISTR   SUBCASE 2

G R I D   P O I N T   F O R C E   B A L A N C E

POINT-ID	ELEMENT-ID	SOURCE	T1	T2	T3	R1	R2	R3
131040	122020	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131040	122025	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131040		*TOTALS*	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]
131045		F-OF-SPC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
131045	122025	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131045	122030	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131045		*TOTALS*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
131046		F-OF-SPC	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]
131046	122025	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131046	122030	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131046		*TOTALS*	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]
131051		F-OF-SPC	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]
131051	122030	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131051	123005	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131051		*TOTALS*	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]
131052		F-OF-SPC	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]
131052	122030	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131052	123005	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131052		*TOTALS*	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]
131057		F-OF-SPC	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]
131057	123005	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131057		*TOTALS*	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]
131058		F-OF-SPC	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]
131058	123005	HEXA	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
131058		*TOTALS*	[illegible]	[illegible]	[illegible]	0.0	0.0	[illegible]

APPENDIX N

ACRONYM DEFINITIONS

1. AFFDL - Air Force Flight Dynamics Laboratory
2. AFML - Air Force Materials Laboratory
3. AGARD - Advisory Group for Aerospace Research and Development (NATO)
4. AHS - American Helicopter Society
5. AIAA American Institute for Aeronautics and Astronautics
6. ASTM - American Society for Testing and Materials
7. DTIC - Defense Technical Information Center
8. GIDEP - Government Industry Data Exchange Program
9. NASA - National Aeronautics and Space Administration
10. NATO - North Atlantic Treaty Organization
11. SAMPE - Society for the Advancement of Materials and Process Engineering
12. STAR - Scientific and Technical Aerospace Report
13. TAB - Technical Abstract Bulletin
14. USAAMRDL - U.S. Army Air Mobility Research and Development Laboratories
15. USAMMRC - U.S. Army Materials and Mechanics Research Center

APPENDIX O

STRESS ANALYSIS

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO.
PREPARED BY APC 9/2/80	CHECKED BY	MODEL NO.
SUBJECT Composite Joint Test, Panel "A"		

INTRODUCTION

This report summarizes the static and fatigue strengths of the joint and fitting test specimens.

Section 1 covers the wrapped Tension Fitting (Tailboom-to-Fuselage Attachment), Type A.

Section 2 covers the Gearbox Attachment Fitting, Type D.

Section 3 covers the Seat Attachment Fitting, Type K.

Static and fatigue analyses are included for types A and D. No fatigue analysis was included for type K since only static tests were conducted. Loading conditions used for analysis are identical to the baseline metal part loads. 16 B

The purpose of the program was to study the feasibility of constructing such joints and fittings and predicting the static and fatigue strength of the fittings for application to future aircraft.

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO.
PREPARED BY APC 9/2/80	CHECKED BY	MODEL NO.
SUBJECT		

REFERENCES

1.0 K.L. Reifsnider and K.N. Louraitis; Fatigue of Filamentary Composite Materials, ASTM Special Technical Publication 636, 1977.

2.0 Advanced Composite Design Guide, 3rd Rev., 1977.

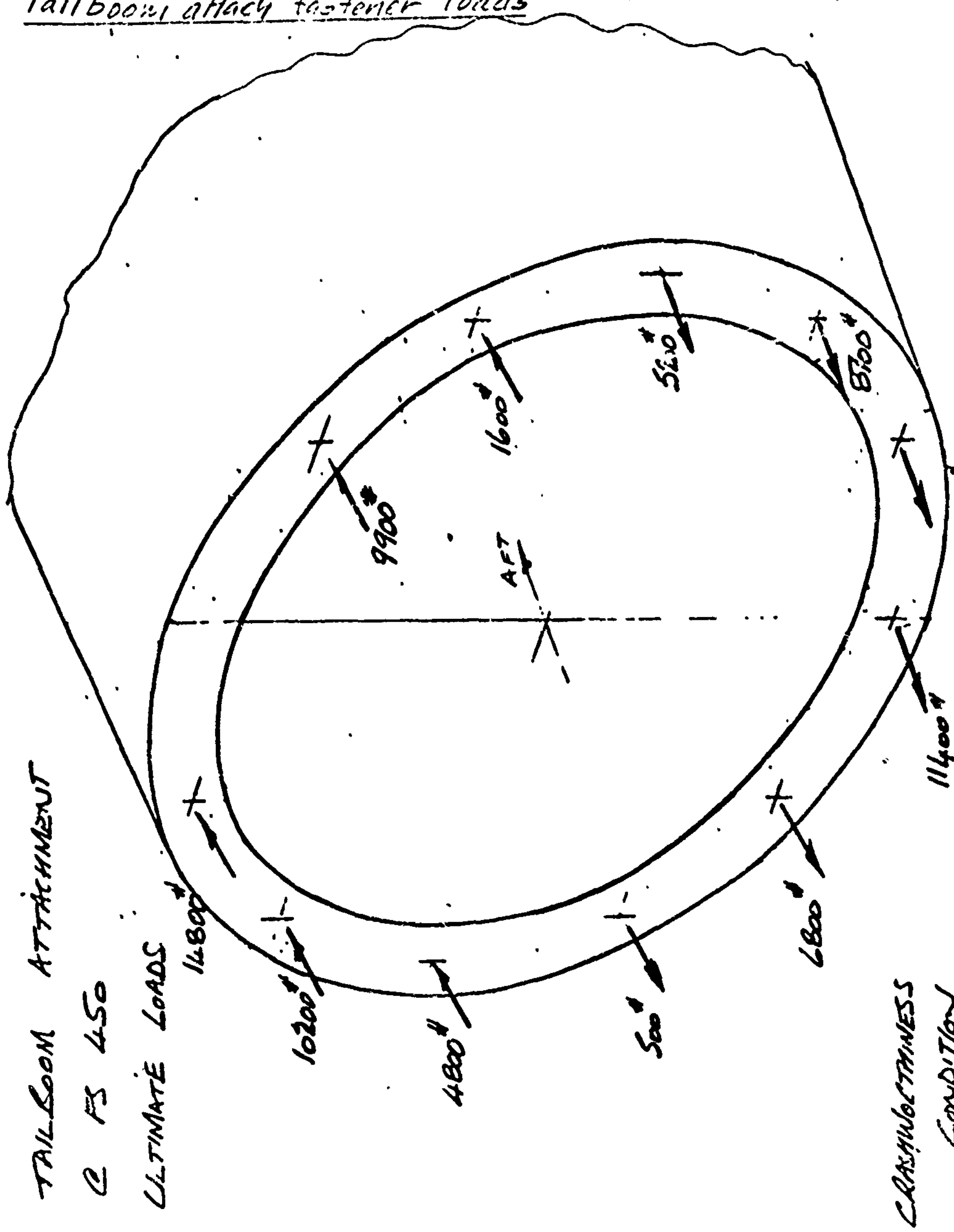
REPORT TITLE Advanced Concepts for Composite Joints and Fittings		REPORT NO.
PREPARED BY APC 9/2/80	CHECKED BY	MODEL NO.
SUBJECT Composite Joint Test Panel "A"		

DISCUSSION

The design of a composite tailboom-to-fuselage attachment was investigated. The geometry of the joint and the load levels correspond to those of the YAH-64 helicopter. The test specimen was designed to withstand the maximum static loads experienced by the metal tailboom (crashworthiness condition). Fatigue endurance limits (E.L.) were then determined.

REPORT TITLE Advanced Concepts For Composite Joints & Fittings	REPORT NO.
PREPARED BY HC 9/2/80 — CHECKED BY	MODEL NO.
SUBJECT Composite Joint Test- Panel 'A'	

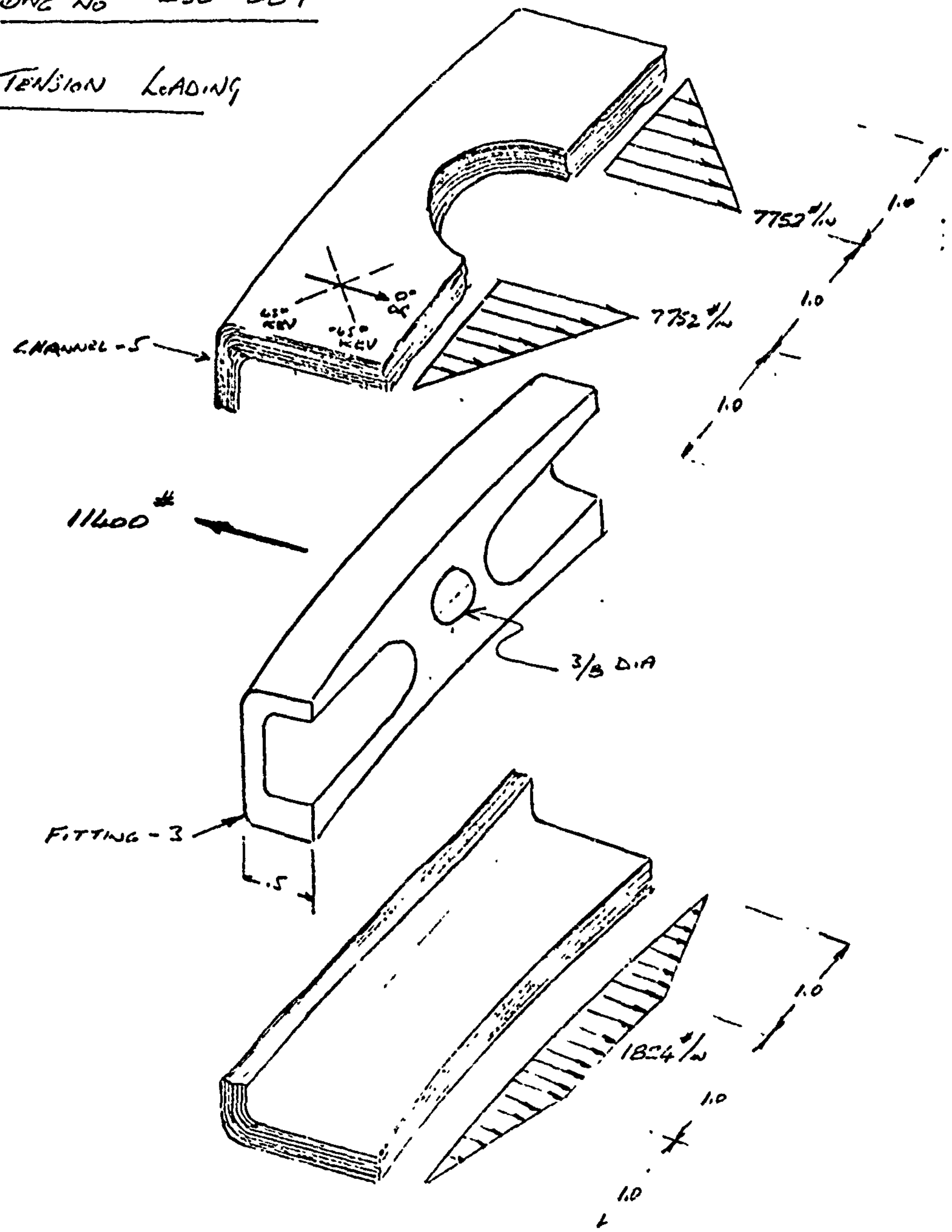
Tailboom attach fastener loads



REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FITTINGS		REPORT NO.
PREPARED BY B. J. SPENCER	CHECKED BY	MODEL NO.
SUBJECT COMPOSITE JOINT TEST PANEL A		REV A

DWG No 430-009

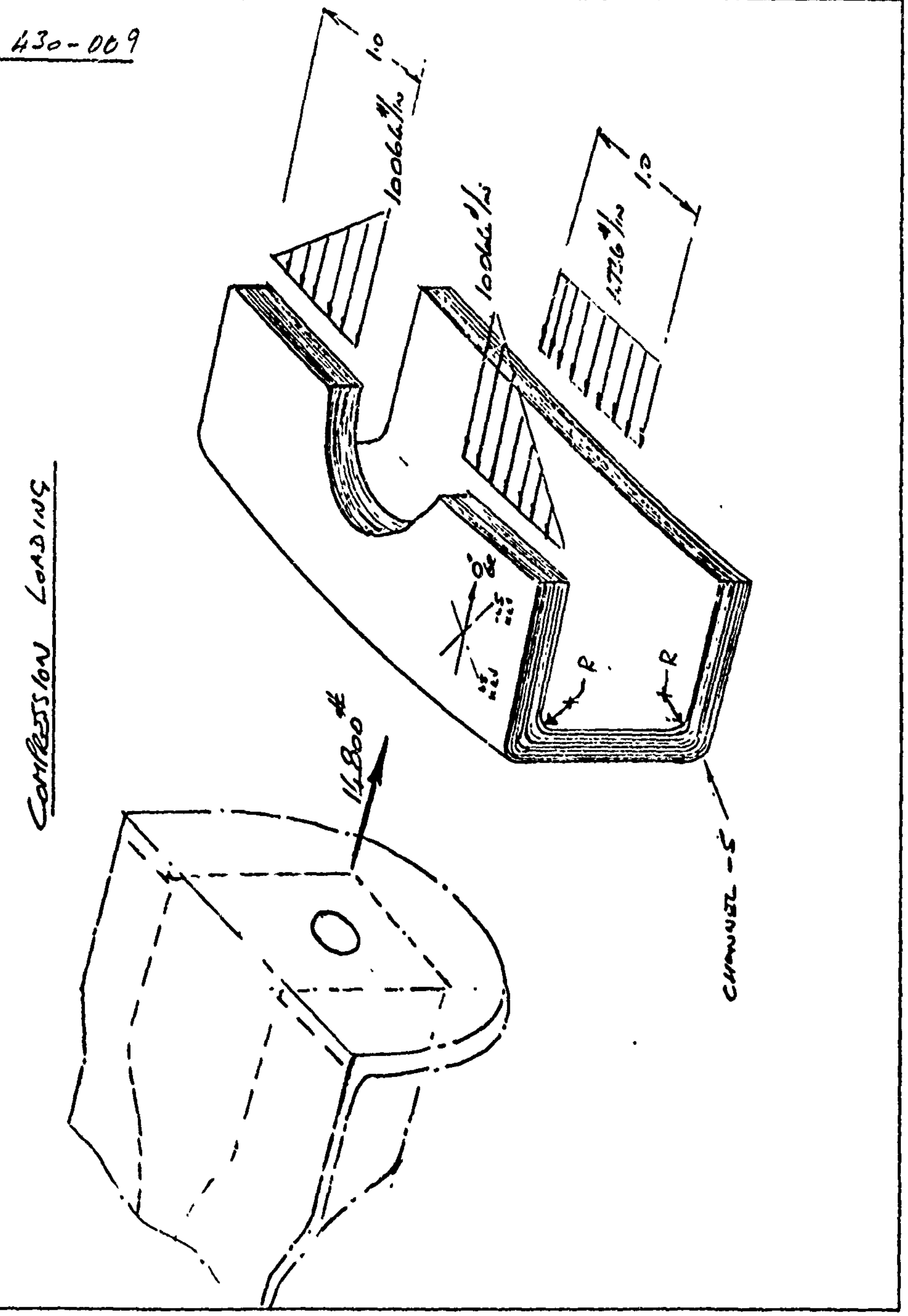
TENSION LOADING



REPORT TITLE		REPORT NO.
ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FITTINGS		
PREPARED BY B. J. SPENCER	CHECKED BY	MODEL NO.

SUBJECT COMPOSITE JOINT TEST PANEL A — Rev A

DWG No 430-009



REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FITTINGS		REPORT NO.
PREPARED BY B. J. SPENCER	CHECKED BY	MODEL NO.
SUBJECT COMPOSITE JOINT TEST PANEL A		Rev A

DWG No 430-009

CHANNEL -5

LAMINATE $(.5_{0°GR} / .5_{\pm 45°GR})$ $t = .176$

TAPE CLOTH

16plies/.015 8plies/.013

MAX COMPRESSION LOAD INTENSITY = 10064 #/IN
MAX TENSION LOAD INTENSITY = 7752 #/IN } ADJACENT TO CUTOUT

STRESSES IN 0° GR

MAX $\sigma_{COMP} = \frac{10064}{.088} = 114000$ PSI

Knock down factor due to small radius

MAX $\sigma_{TEN} = \frac{7752}{.088} = 88100$ PSI

Predicted ten failure ld $\} = \frac{195}{88.1} \times 2 \times 11400 \times .45 = 22,800$ #

FIG 17.03

ALLOWABLES

$\sigma_{cu} = 129000$ PSI

$\sigma_{tu} = 195000$ PSI

$V_f = .60$

0° T300 GRAPHITE

$M.S. = \frac{129000}{114000} - 1 = \boxed{+.13}$ COMP

LOAD BETWEEN CHANNEL & OUTER FACE SHEET

MAX $N_x = \frac{14800}{6 \times 2} = 1233$ #/IN PER FACE SHEET

50% OF THIS LOAD IS SHEARED INTO CHANNEL IN .5 IN

$f_{SHEAR} = 1233$ PSI

REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FITTINGS		REPORT NO.
PREPARED BY B. J. SPENCER	CHECKED BY	MODEL NO.
SUBJECT COMPOSITE JOINT TEST PANEL A		Rev A

DWG No 430-009

LAMINA STRAINS $\qquad N_x = \frac{-14800}{6} = -2467\ \#/\text{in}$

FACE SHEETS ARE $(\pm 45°\ KEV, \pm 15°\ GR)_s$ $\qquad t_f = .044$

$$\begin{bmatrix} \epsilon_x \\ \epsilon_y \\ \gamma_{xy} \end{bmatrix} = \begin{bmatrix} \frac{1}{8.71} & -\frac{.961}{8.71} & 0 \\ -\frac{.961}{8.71} & \frac{1}{1.86} & 0 \\ 0 & 0 & \frac{1}{2.4} \end{bmatrix} \times \begin{bmatrix} -28000 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} -3214 \\ 3089 \\ 0 \end{bmatrix}$$

$\frac{+15°}{GR}$

$$\begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \frac{\gamma_{12}}{2} \end{bmatrix} = \begin{bmatrix} .933 & .067 & -.5 \\ .067 & .933 & .5 \\ .25 & -.25 & .866 \end{bmatrix} \times \begin{bmatrix} -3214 \\ 3089 \\ 0 \end{bmatrix} = \begin{bmatrix} -2792 \\ 2667 \\ -1576 \end{bmatrix}$$

$\frac{+45°}{KEV}$

$$\begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \frac{\gamma_{12}}{2} \end{bmatrix} = \begin{bmatrix} .5 & .5 & -1 \\ .5 & .5 & 1 \\ .5 & -.5 & 0 \end{bmatrix} \times \begin{bmatrix} -3214 \\ 3089 \\ 0 \end{bmatrix} = \begin{bmatrix} -63 \\ -63 \\ -3152 \end{bmatrix}$$

REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FITTINGS		REPORT NO.
PREPARED BY B. J. SPENCER	CHECKED BY	MODEL NO.

SUBJECT COMPOSITE JOINT TEST PANEL A   Rev A

DWG No 430-009

FITTING -3

MATL - STEEL HT 160 KSI

SECTION THROUGH 3/8 DIA HOLE

$$B.M. = \frac{7752}{2}(.833) + \frac{1824}{2}(.833) + \frac{1824}{2}(.25) = 4217 \text{ in-lb}$$

$$f_b = \frac{6M}{bt^2} = \frac{6 \times 4217}{.6\,(.5)^2} = 169000 \text{ PSI}$$

$$F_b = 240000 \text{ PSI}$$

$$M.S. = \frac{240,000}{169,000} - 1 = \boxed{+.42}$$

BENDING

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO.
PREPARED BY APC 8/27/80	CHECKED BY	MODEL NO.
SUBJECT Composite Joint Test Panel "A"		

Fatigue allowables.

Shown below is coupon test data for ±45° Kevlar/epoxy

STATISTICAL ANALYSIS OF THE ±45° CROSS PLY KEVLAR-49 EPOXY IN TENSION-TENSION FATIGUE.

SPEC. NO.	N CYCLES @ FAILURE	CYCLIC STRESS @ FAILURE	S_a* CYCLIC STRESS @ 5×10^7 N	$(\bar{S}-S_a)^2$ $\times 10^{-3}$
-4	51,810	5625	4175	0.625
-5	2.5115×10^6	4662	4612	169.744
-17	2.2355×10^6	4131	4072	16.384
-18	2.1538×10^6	4001	3940	67.600
		Σ	16,799	254.353

MEAN ENDURANCE LIMIT, $\bar{S} = \frac{16,799}{4} \cong 4200$ PSI

UNBIASED STANDARD DEVIATION, $\sigma_{UB} = \sqrt{\frac{\Sigma[(\bar{S}-S_a)^2]}{n-1}} =$

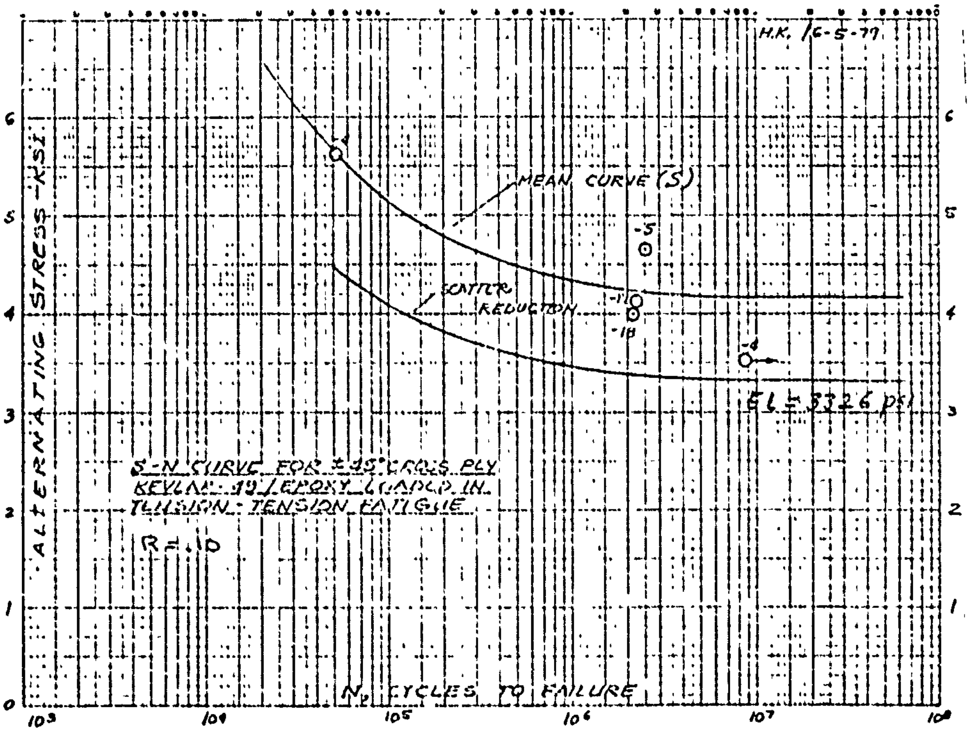
$$= \sqrt{\frac{254.353}{4-1}} = 291.177$$

$$\bar{S} - 3\sigma_{UB} = 4200 - 3(291.177) \quad = 3326 \text{ PSI}$$

* Specimen EL.

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO.
PREPARED BY ADC 8/27/80	CHECKED BY	MODEL NO.
SUBJECT Composite Joint Test Panel "A"	Rev "A"	

Fatigue Allowables



$F_{XTU} = 17,390$ psi } Kevlar ±45° Ref test data
$F_{XCU} = 10500$ psi }

$$\text{COM. E.L. for } \pm 45^\circ \text{ Kevlar} = \frac{10.5}{17.4} \times 3326 = 2007 \text{ psi}$$

REPORT TITLE		REPORT NO.
Advanced Concepts for Composite Joints & Fittings		
PREPARED BY APC 2/28/80	CHECKED BY	MODEL NO
SUBJECT Composite Joint Test Panel A		

Graphite Fatigue Allowables

Ref. Fatigue of Filamentary Composite Materials
ASTM Special Technical Publication 636
By K L Reifsnider and K N Lauraitis, 1977

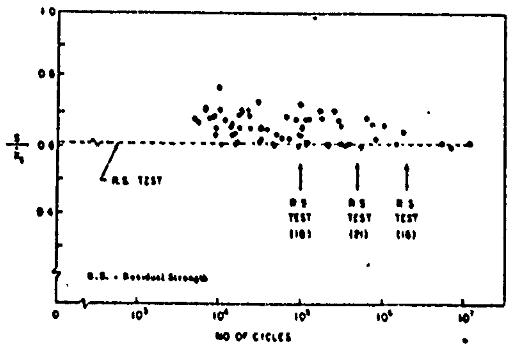


FIG 3—S N relationship.

Notes

1., The maximum fatigue stress S is normalized with respect to the static strength $\hat{X}s$.

2., Test material was unidirectional graphite/epoxy T300/5208 with a nominal fiber content of 70 percent by volume.

3., Stress Ratio = .10

Review of the curve above indicates that the allowable maximum fatigue stress can be taken as 60 percent of the ultimate static strength (for a stress ratio = .10).

For V_f = .. F_{tuc} = 195,000 psi

195000 x .6 x .75 x .80 x .45 = 31,650 psi 0° Ten alt

scatter factor — environment factor — For R=.10

From test data for ±25° the ult ten to ult comp ratio is about .30

$\frac{123}{115}$ x .3 x 31600 = 6900 psi compression E.L. for ±15° graphite

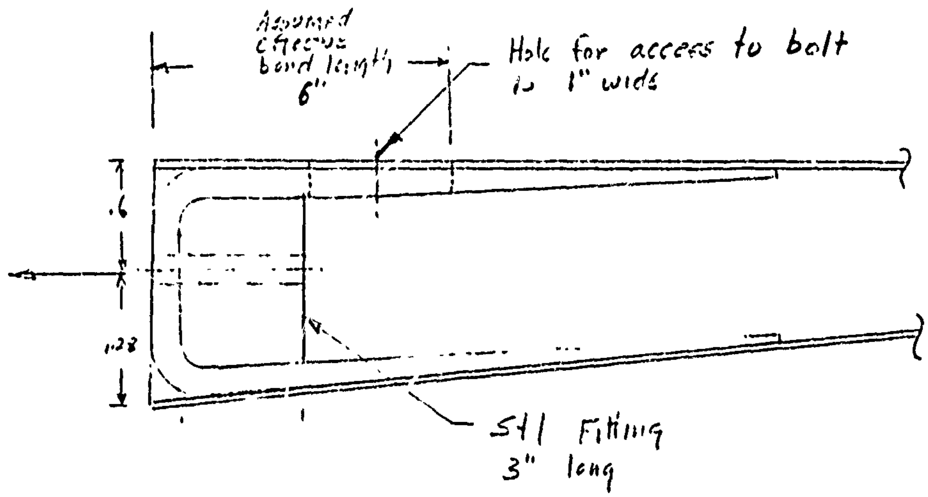
0° to 15° reduction

Predicted E L ξ = (2007 + 6000)(.0044 x 11.?) = 4100 #

REPORT TITLE	REPORT NO.
Advanced Concepts for Composite Joints & Fittings	

PREPARED BY	CHECKED BY	MODEL NO.
LPE 8/25/80		

SUBJECT: Composite Joint Test Panel "A"



View A

E.L. for face-slit bond $= 6(3+3) \times 225 = 8100^{\#}$ "D" section fitting, fatigue curve for lap joint Pg 20.15

For the total panel $\Sigma = 2 \times 8100 = 16{,}200^{\#}$ max fatigue ld

Predicted E.L. $\Sigma = \dfrac{16200 - .05 \times 16200}{2} = 7695^{\#}$ All ld

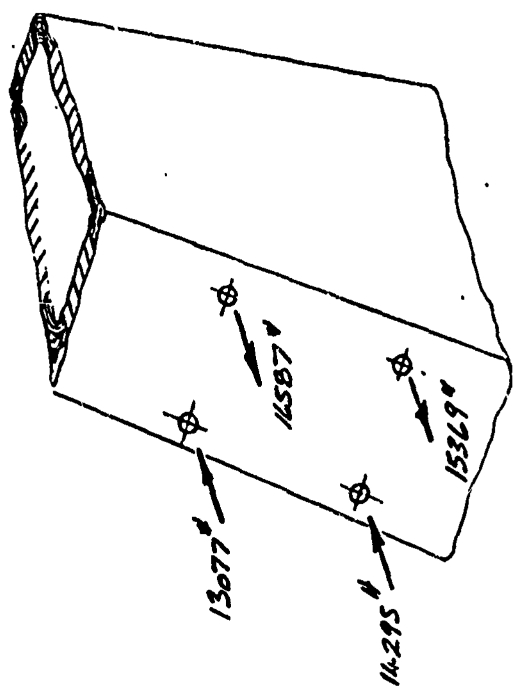
REPORT TITLE Advanced Concepts for Composite Joints and Fittings		REPORT NO.
PREPARED BY APC 9/2/80	CHECKED BY	MODEL NO.
SUBJECT Composite Joint Test Section D		

DISCUSSION

The design of a composite vertical stabilizer/tail rotor gearbox attachment for the YAH-64 helicopter was investigated. The test specimen was designed to meet the static load requirements of the metal vertical stabilizer (blade strike condition). Fatigue endurance limits (E.L.) were then determined.

REPORT TITLE COMPOSITE TAIL SECTION STRESS ANALYSIS		REPORT NO.
PREPARED BY B.J. Spencer	CHECKED BY	MODEL NO.
SUBJECT VERTICAL STABILIZER		Re: A

VERTICAL STABILIZER
UPPER 90° GEARBOX ATTACHMENT
ULTIMATE LOADS



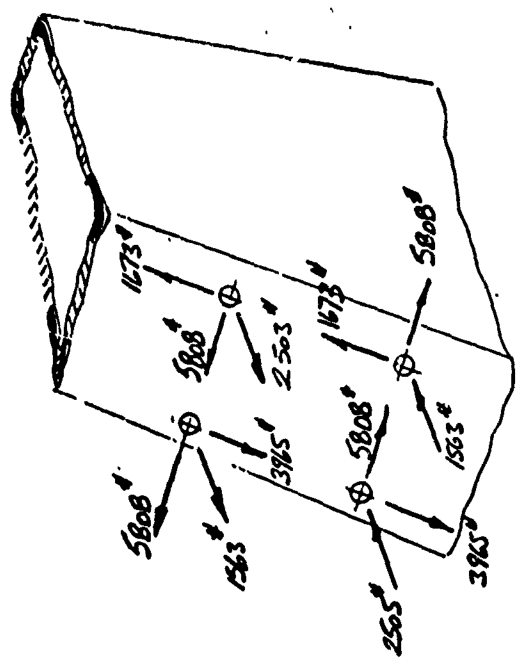
CONDITION 0° STRIKE

REPORT TITLE Composite Tail Section Stress Analysis		REPORT NO.
PREPARED BY B.J. Spencer	CHECKED BY	MODEL NO.
SUBJECT Vertical Stabilizer		

VERTICAL STABILIZER

UPPER 90° GEARBOX ATTACHMENT

ULTIMATE LOADS



CONDITION 270° STRIKE

17
F

REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FTGS.

REPORT NO.

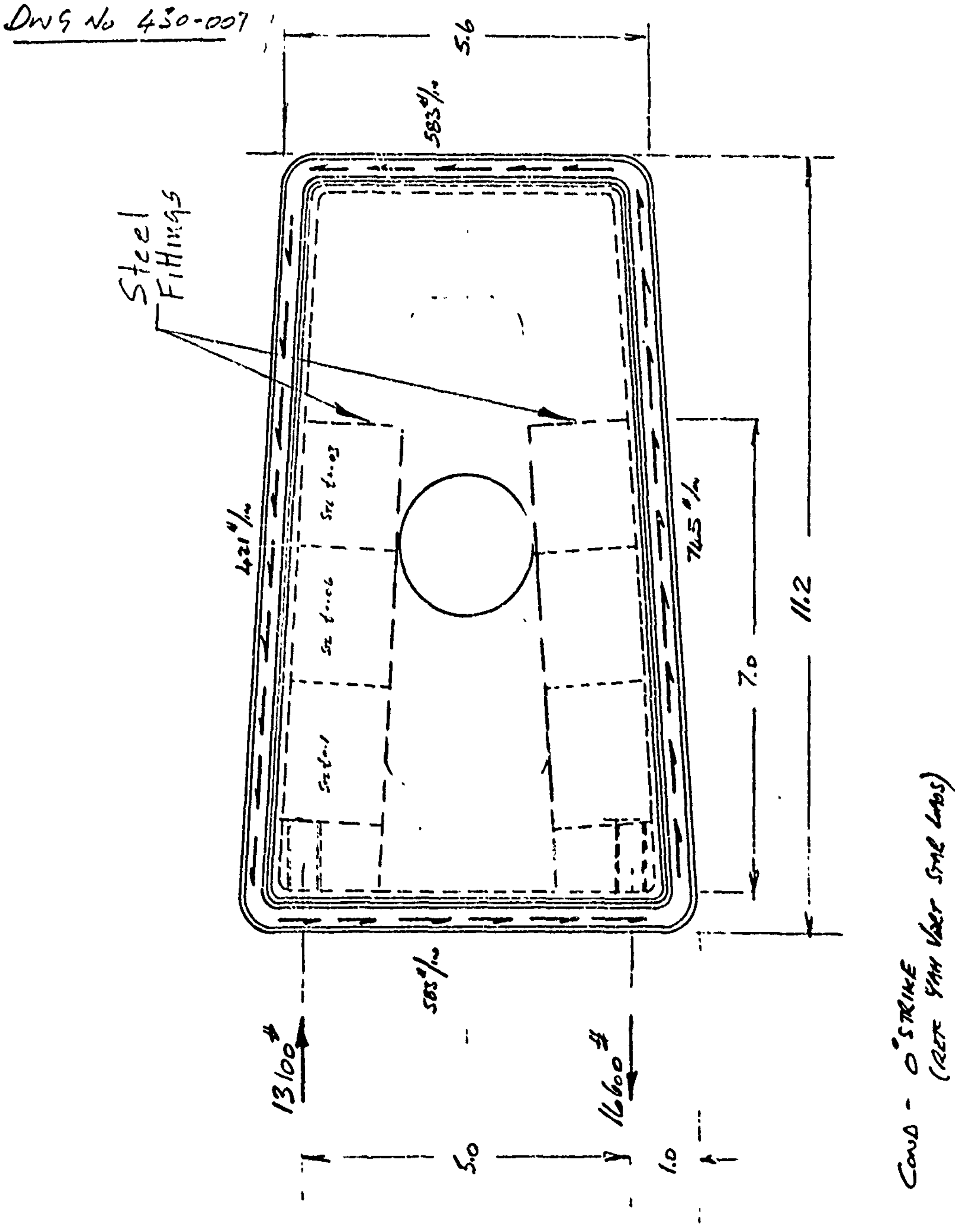
PREPARED BY E. J. SPENCER

CHECKED BY

MODEL NO.

SUBJECT COMPOSITE JOINT TEST SECTION D — Rev A

DWG No 430-007



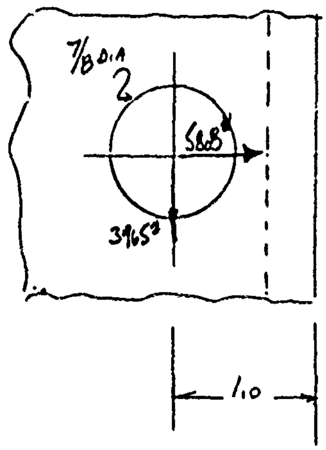
17
B

REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FTGS		REPORT NO
PREPARED BY S J STEVECK	CHECKED BY	MODEL NO.
SUBJECT COMPOSITE JOINT TEST SECTION D	Rev A	

DWG No. 430-007 1

SHEAR TEAR OUT

COND 90° STRIKE

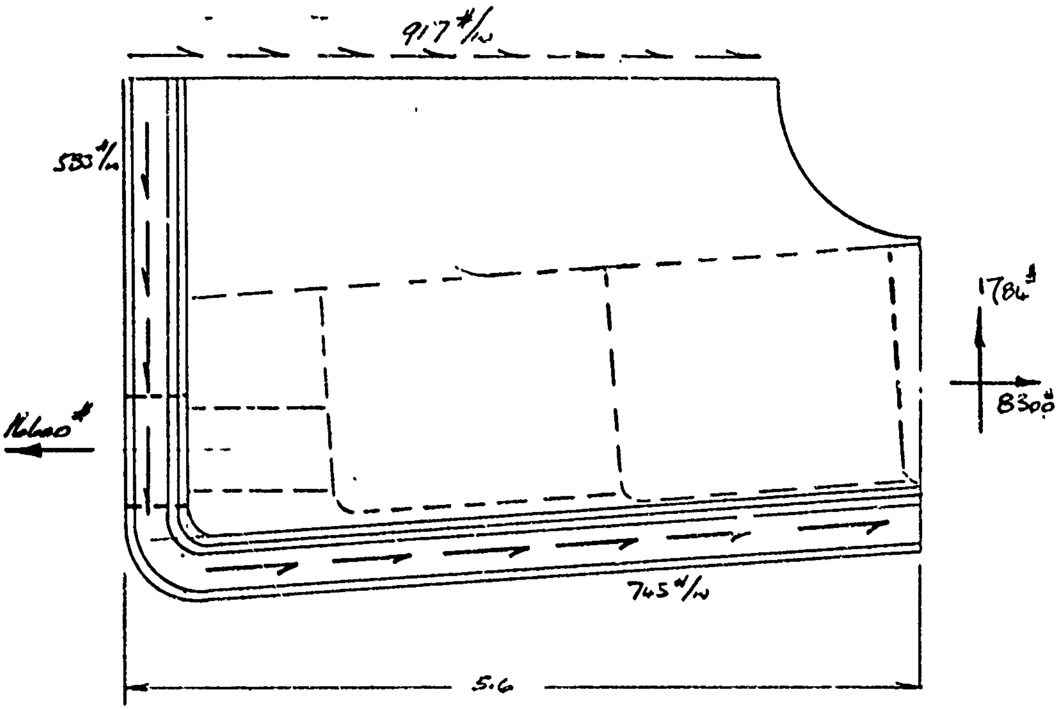


$$f_{su} = \frac{5808}{2(1.0 - \frac{.875}{2}).34} = 15200\ PSI$$

$$F_{su\ 30\% \pm 45} = 15500\ PSI$$

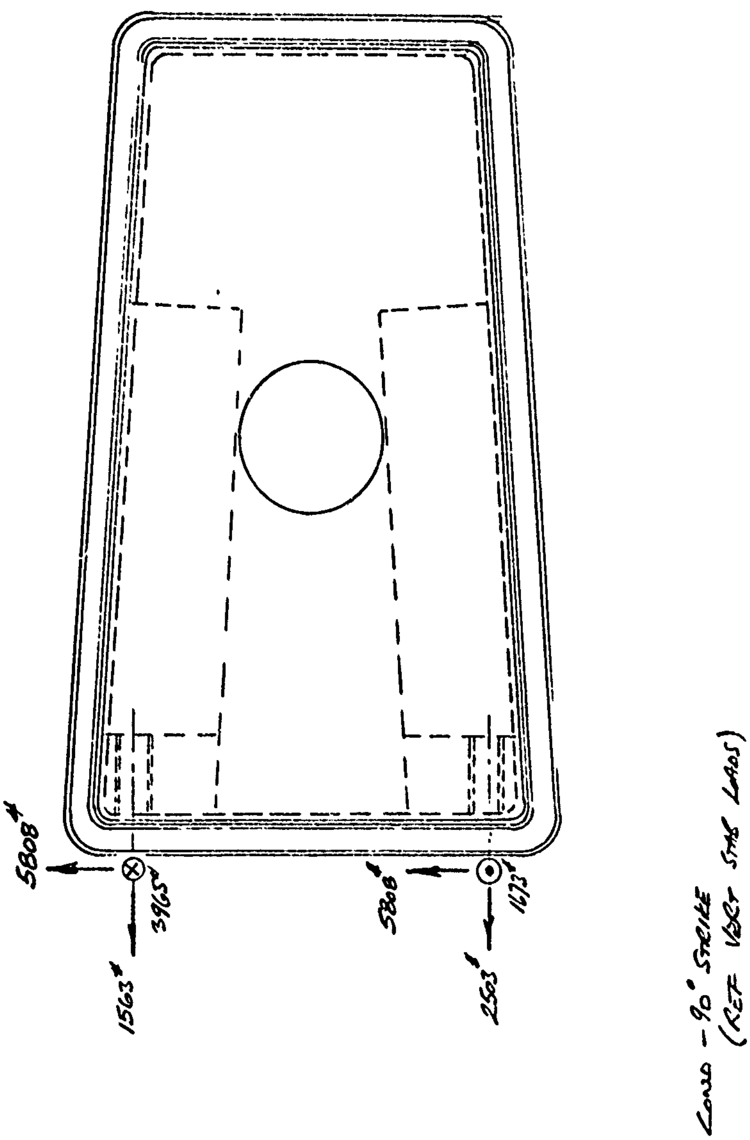
$$M.S. = \frac{15500}{15200} - 1 = \boxed{+.02}$$

REPORT TITLE Composite Joints & Fittings		REPORT NO.
PREPARED BY L. J. Spencer	CHECKED BY	MODEL NO.
SUBJECT DWG No 430-007		Rev A



REPORT TITLE ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FITTINGS		REPORT NO.
PREPARED BY E. J. Stenker	CHECKED BY	MODEL NO.
SUBJECT COMPOSITE JOINT TEST SECTION D		Rev A

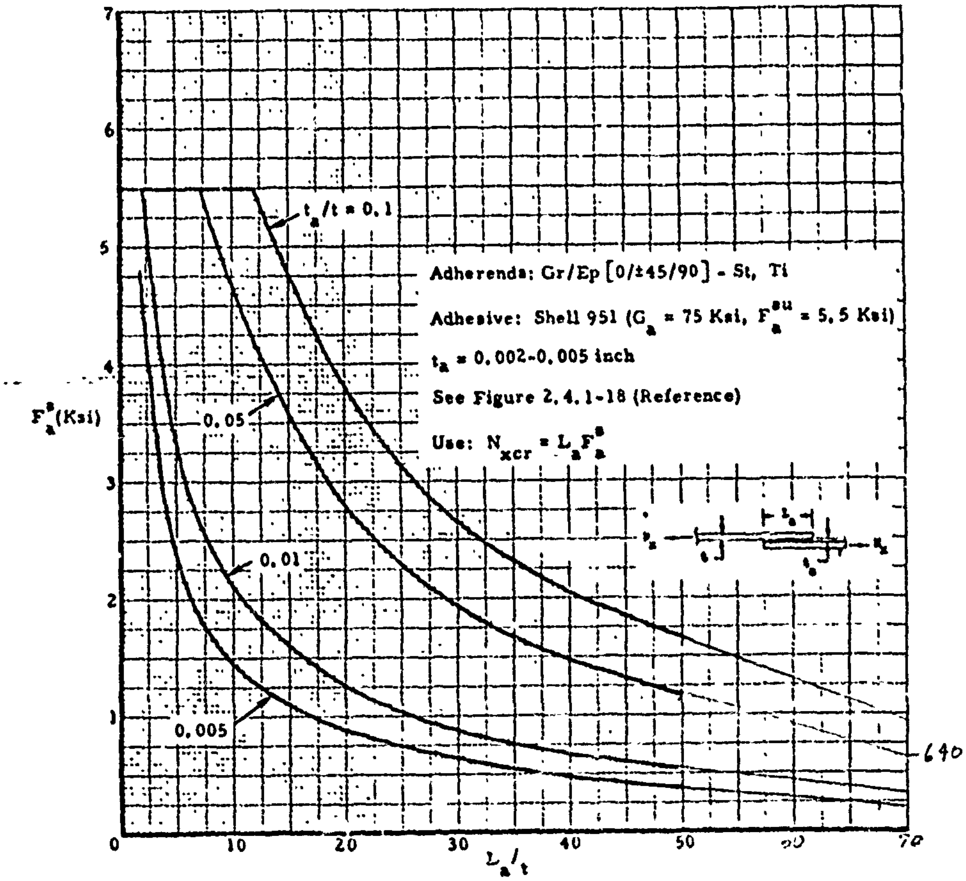
DWG No 430-007



REPORT TITLE		REPORT NO
Advanced Concepts for Composite Joints and Fittings		
PREPARED BY: IDC	CHECKED BY	MODEL NO
SUBJECT: Composite Joint Test Section D		

Lap Shr Allowable

GRAPHITE/EPOXY



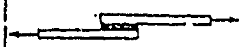
ALLOWABLE STRENGTH CURVES, SINGLE-LAP SHEAR JOINT
Gr/Ep-TO-STEEL OR TITANIUM, SHELL 951

Ref 2

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO.
PREPARED BY APC 8/05/80	CHECKED BY	MODEL NO
SUBJECT Composite Joint Test Section D		Rev-A

Steel Fitting to Composite; Bond Fatigue Analysis

Estimated
Room Temperature Allowable
Alternating Stress
FM-1000 Adhesive



Stress Ratio: 0.10

Adherend: 2024 T-3
. Clad Aluminum

Cure: 2 Hours 350° F
25 psi

Length of Lap	Allowable Alt. Stress $\sigma_{Alt.}$	Number Of Stress Cycles N
.50 in.	241 psi	10^7
1.00 in.	190 psi	10^7
4.00 in.	109 psi	10^7

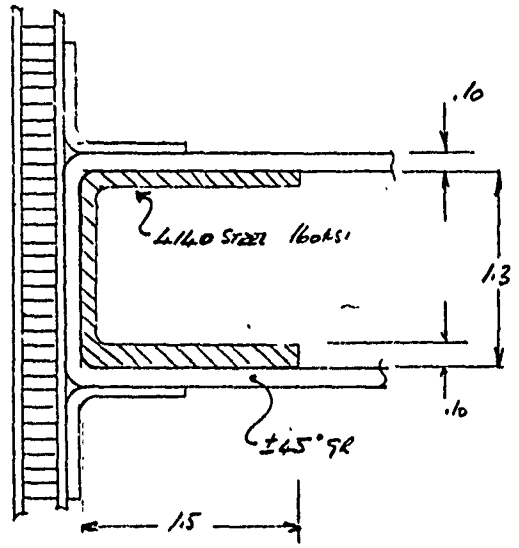
The above table shows allowable alternating stress for various lap-Joint lengths.

Data given in the Advanced Composite Design Guide for 0.5" lap joint is reduced by the following factor $\frac{109}{241} = .45$ . . Its assumed that at 10^7 cycles the curve is flat.

REPORT TITLE		REPORT NO.
ADVANCED CONCEPTS FOR COMPOSITE JOINTS & FTGS		
PREPARED BY R J SPENCER	CHECKED BY	MODEL NO.
SUBJECT COMPOSITE JOINT TEST SECTION D		Rev A

DWG No 430-007

BOND ATTACHMENT OF FTG (-3) TO GR CHANNEL (-5)



BOND AREA $= (2 \times 1.5 + 1.3)\ 7 = 30\ in^2$

MAX LOAD $= 16600^{\#}$

AVERAGE BOND STRESS $= \frac{16600}{30} = \underline{550\ psi}$

For a lap shear joint 7" long

$\frac{t_a}{t} = \frac{.005}{.10} = .05$

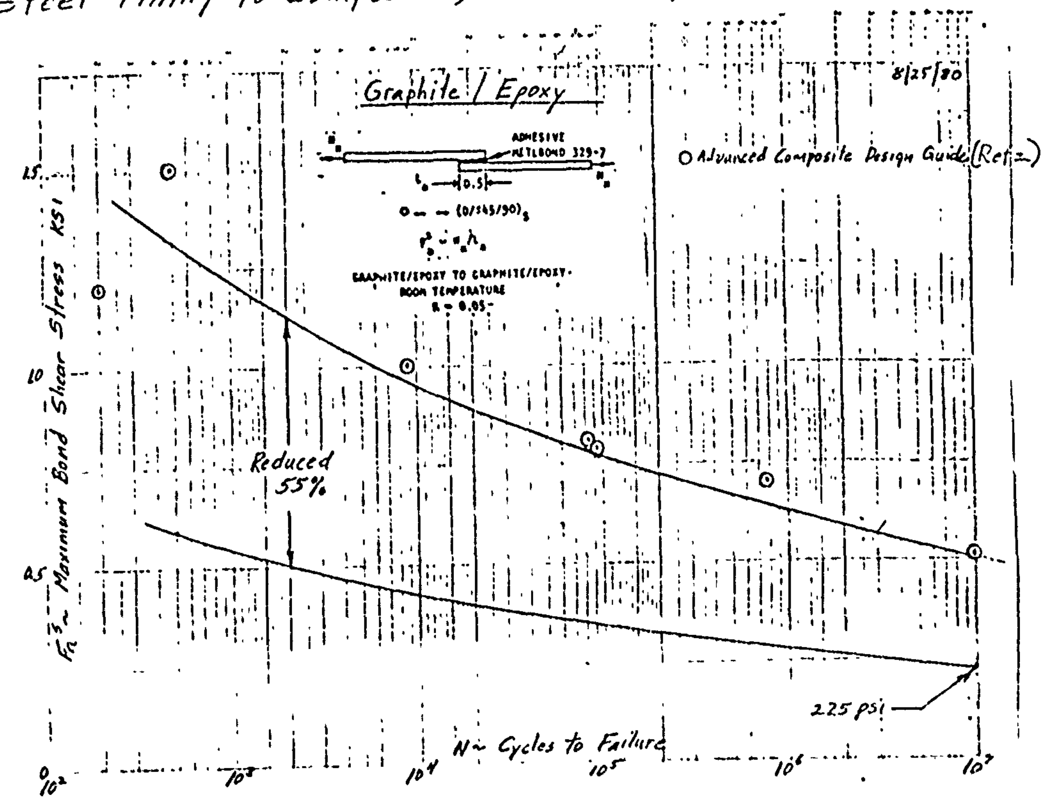
$\frac{L_a}{t} = \frac{7}{.10} = 70$ Ref. test set up $MS = \frac{640}{550} - 1 = \underline{.16}$

Predict a failure load of $= 1.16 \times 3300$ Ref pg 20.10 $= 3828^{\#}$

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO.
PREPARED BY 7PC 8/25/80	CHECKED BY	MODEL NO.

SUBJECT Composite Joint Test Section D Rev A

Steel Fitting to Composite, Bond Fatigue Ana.



225 psi Predicted E.L.

REPORT TITLE		REPORT NO.
Advanced Concepts for Composite Joints and Fittings		
PREPARED BY APC 9/2/80	CHECKED BY	MODEL NO.
SUBJECT YAH-64 Upper Co-Pilots Seat Fitting		

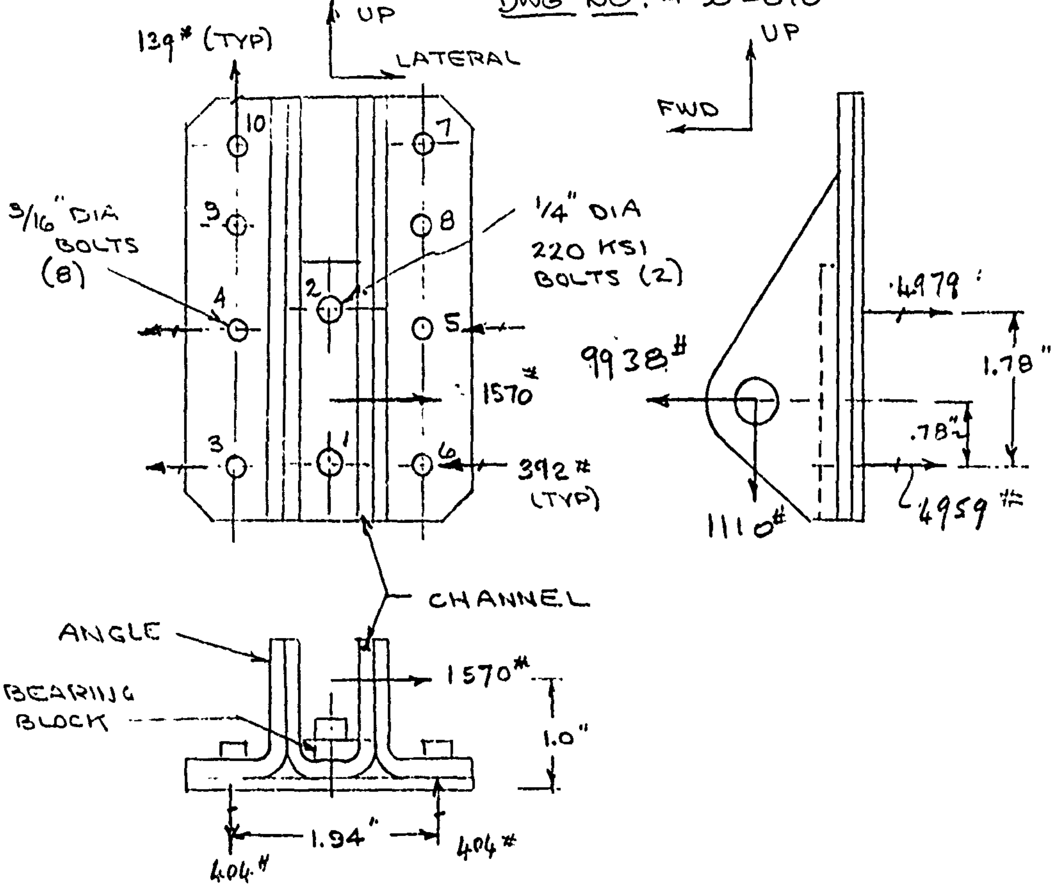
DISCUSSION

A composite seat attachment fitting was designed to investigate the feasability of fabricating such a part using advanced composite materials. The fitting was designed for the YAH-64 loads (crashworthiness condition).

REPORT TITLE		REPORT NO.
Advanced Concepts for Composite Joints & Fittings		REV A
PREPARED BY D. MANCILL	CHECKED BY	MODEL NO.

SUBJECT
YAH-64 UPPER CO-PILOT'S SEAT FITTING

DWG NO. 430-010



LOAD PATHS

1.) THE 1/4" DIA (220 KSI) BOLTS IN THE CHANNEL CARRY ALL THE VERTICAL AND FWD LOADS. THE FIBERS OF THE CHANNEL WRAP AROUND THE BEARING BLOCK, THUS ENSURING AN EFFECTIVE MECHANICAL LOCK OF THE FITTING TO THE BACK-UP STRUCTURE.

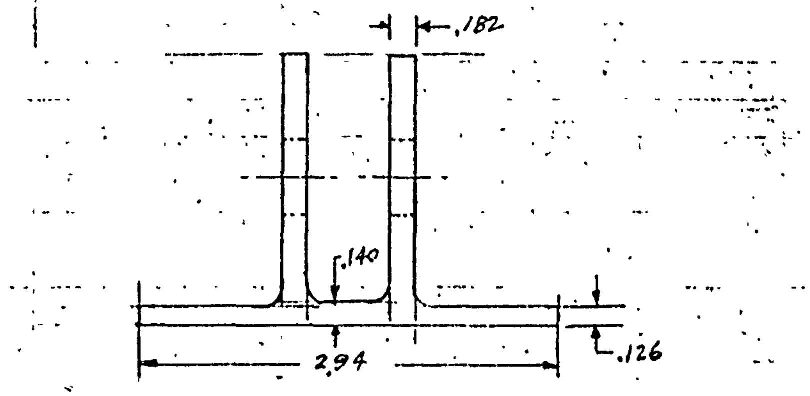
2.) THE 3/16" DIA. BOLTS WITH THE ANGLES CARRY THE LATERAL LOAD.

REPORT TITLE		REPORT NO.
Advanced Concepts For Composite Joints & Fittings		
PREPARED BY *AFC* *8/28/80*	CHECKED BY	MODEL NO.
SUBJECT *YAH-64 Upper Co-Pilots Seat Fitting*		

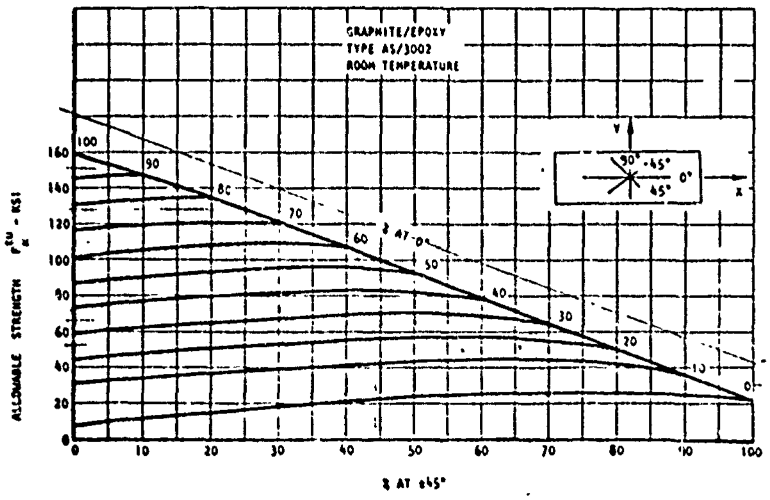
.007/PLY BROADGOODS

ITEM	NO. PLIES	STACKING SEQUENCE	THICKNESS
-3	14	$(0/90)_2/(\pm45)/[(0/90)/(\pm45)]_2\}_s$	.098
-5	12	$[(0/90)_2/(\pm45)]_2\}_s$	.084
-7	6	$[(0/90)_2/\pm45]_s$	.042

.182



CALCULATED THICKNESSES



REPORT TITLE Advanced Concepts for Composite Joints & Fittings | REPORT NO. REV A
PREPARED BY D. MANCILL | CHECKED BY | MODEL NO.
SUBJECT YAH-64 UPPER CO-PILOT'S SEAT FITTING

DWG NO 430-010

REACTIONS

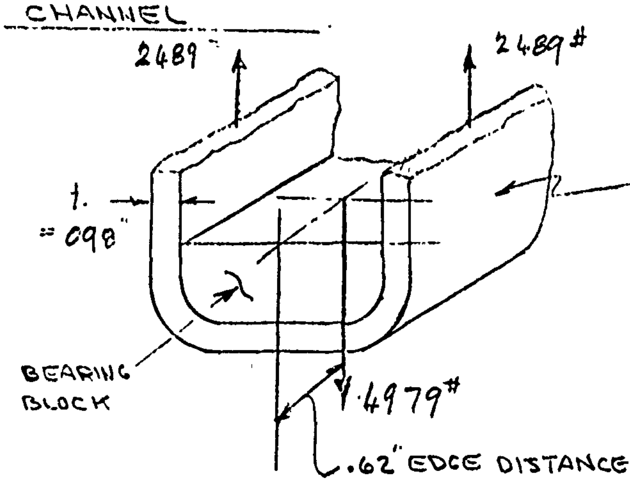
$$R_{①} = \frac{(9938 \times 1.0) - 1110}{1.78} = 4959^{\#}$$

$$R_{②} = \frac{(9938 \times .78) + 1110}{1.78} = 4979^{\#}$$

CONSERVATIVELY ASSUME ONLY BOLTS 3 THRU 6 CARRY THE LATERAL LOAD.

$$R_{③ \to ⑥} = \frac{1570 \times 1.0}{2 \times 1.94} = 404^{\#}$$

CHANNEL

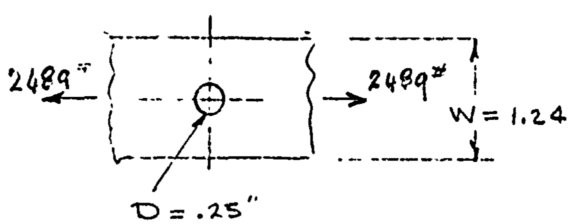


GRAPHITE/EPOXY

25% 0°
25% 90°
50% ±45°

$F_x^t = 63000$ PSI

OPEN-HOLE ALLOWABLE



$$\frac{W}{D} = \frac{1.24}{.25} = 4.96$$

ALLOWABLE GROSS STRESS

$F_x^t = 21500$ PSI

REPORT TITLE Advanced Concepts for Composite Joints & Fittings		REPORT NO. REV A
PREPARED BY D. MANCILL	CHECKED BY	MODEL NO.
SUBJECT YAH-64 UPPER CO-PILOT SEAT FITTING		

CHANNEL CONT'D.

DWG NO 430-010

$$f_t = \frac{P}{A} = \frac{2489.}{1.24 \times .098} = 20500 \text{ PSI}$$

$$M.S. = \frac{21500}{20500} - 1 = \underline{\underline{+.01}}$$

TENSION FAILURE AROUND HOLE

1/4" DIA BOLTS

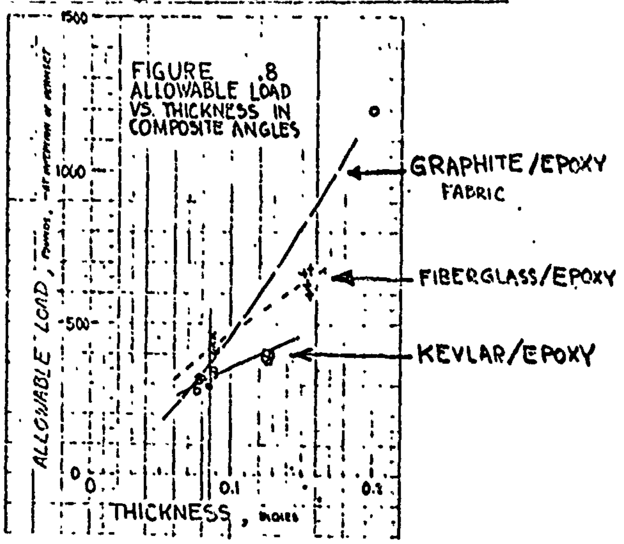
$P_{APPLIED} = 4974^{\#}$

$P_{ALLOWABLE} = 7530^{\#}$ (220 KSI BOLT)
REF MIL-HDBK-5C, PAGE 8-78

$$M.S. = \frac{7530}{4974} - 1 \cong \underline{0.51}$$

ANGLE (GRAPHITE/EPOXY)

COMPOSITE ANGLE TEST RESULTS



25% 0°
25% 90°
50% ±45° } LAY-UP

$P_{APPLIED} = 404^{\#}$

THICKNESS OF ANGLE $= .084"$

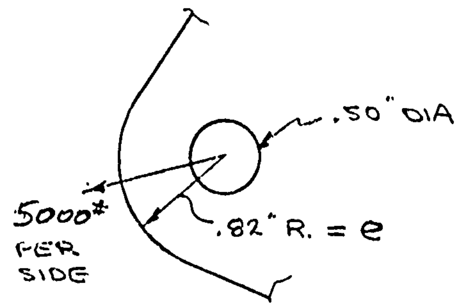
$P_{ALLOWABLE} = 400^{\#}$

$$M.S. = \frac{400}{404} - 1 = \underline{\underline{+.00}}$$

REPORT TITLE		REPORT NO.
Advanced Concepts for Composite Joints & Fittings		Rev A
PREPARED BY D. MANCILL	CHECKED BY	MODEL NO.
SUBJECT YAH-64 UPPER CO-PILOT SEAT FITTING		

LUG ANALYSIS

DWG NO 430-010



$t = .098 + .084 = .182$
(CHANNEL PLUS ANGLE)

$D/t = \frac{.50}{.182} = 2.78$

$e/D = \frac{.82}{.50} = 1.64$

BEARING STRESS $f_B = \frac{5000}{.50 \times .182} = 55000$ PSI

FOR DOUBLE SHEAR JOINT $F_{BR} = 80,000$ PSI

$M.S. = \frac{80,000}{55000} - 1 = +.46$ BEARING

CHECK LUG SHEAROUT STRENGTH

$f^{so} = \frac{P}{2t(e - D/2)} = \frac{5000}{2 \times .182(.82 - .25)} = 24100$ PSI

FOR 50% ±45° $F^{so} = 25,000$ PSI

$M.S. = \frac{25000}{24100} - 1 = +.04$ SHEAROUT

CHECK NET TENSION STRENGTH

NET TENSION STRESS $f_t = \frac{5000}{.182(1.64 - .50)} = 24100$ PSI

$E = 7.20 \times 10^{+6}$ $\epsilon_t = \frac{24100}{7.2 \times 10^{+6}} = 3350 \times 10^{-6}$

ALLOWABLE STRAIN $= 4000 \times 10^{-6}$

$MS = \frac{4000}{3350} - 1 = +.20$ NET TENSION